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AN
ESSAY
ON THE
MEDICINAL PROPERTIES
OF
FACTITIOUS AIRS.

WITH AN
APPENDIX,
ON THE NATURE OF BLOOD.

BY
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PREFACE.

IT is not quite forty years ſince the artificial aerial fluids began to be adminiſtered as remedies to the human body. The uncertainty, and the errors of the early applications, rendered the progreſs of the practice ſlow and doubtful; nor has the experience, or the ſucceſs of recent and more numerous practitioners, been ſufficient to determine the preciſe power of the aerial fluids, or to diſſipate the doubts which are ſtill entertained concerning their uſe.

The deſire of extricating the ſubject from the conflict of contrary opinions, eſtabliſhed prejudices, and oppoſite intereſts, has induced the Author, perhaps too haſtily, to publiſh the preſent work, which, in every ſenſe of the word, deſerves the epithet of imperfect. But he hopes that the importance of an object ſo highly intereſting to the human ſpecies, may palliate, if not juſtify, the imperfections of the performance, which might, perhaps, have been leſs excuſable in other ſubjects.

To exhibit a conciſe view of aſcertained facts, to ſeparate them from ſuppoſitions and hypotheſes, and to point out the ways of inveſtigating the farther uſe of factitious airs, has been the Author's principal aim in the compilation of the preſent Eſſay.

In the courſe of his inquiries, he has frequently found cauſe to admire the ingenuity, the caution, and the perſeverance of ſeveral gentlemen, who either have adminiſtered the aerial fluids, or have otherwiſe exerted themſelves in the promotion of their uſe. Yet he has taken particular care to avoid paying them any compliments, or even making frequent uſe of their names, leſt his deſire of promoting the ſubject ſhould be apparently converted into an endeavour of promoting the intereſt of certain practitioners.

The firſt four chapters contain ſuch facts as may be of theoretical uſe in the applications of aeriform fluids, and in the inveſtigation of their action, independent on medical caſes. The fifth chapter exhibits a conciſe view of the modern theory of aerial fluids, and of the proceſſes that are principally depending thereon, ſuch as reſpiration, combuſtion, &c. The ſixth and ſeventh chapters ſhew the practical application of thoſe fluids by way of remedies to the human body; and this practice is exemplified in the eighth chapter, in which a ſelect number of authentic caſes is related. The ninth, or laſt chapter, contains ſeveral practical remarks, hints, &c. which could not be conveniently inſerted in the preceding part of the work.

Laſtly, a diſſertation on the nature and properties of blood has been added by way of Appendix, that fluid being evidently and principally concerned in reſpiration, and in the general dependance of the animal exiſtence on the aerial fluids.

By the mixt uſe of the old and the new chemical names in various parts of the work, the author imagines that his meaning may be rendered leſs equivocal, and more generally intelligible; for at a time when the old names are not quite diſuſed, and the new chemical nomenclature not univerſally underſtood, it is difficult to determine whether the greateſt number of readers may remain ſatisfied with the excluſive uſe of either.

Wells Street,
January the 8th, 1798.

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AN ESSAY ON THE MEDICINAL PROPERTIES OF FACTITIOUS AIRS.

CHAPTER I.

The principal Properties of thoſe AIRS, *or permanently elaſtic Fluids, which have been applied as Remedies to the Human Body.*

THE philoſophical inveſtigations of the two laſt centuries, and particularly of the preſent age, have aſcertained the exiſtence of various elaſtic fluids, analogous to common air, with reſpect to elaſticity and inviſibility; but otherwiſe eſſentially different from it, as alſo different from each other; ſuch are the *dephlogiſticated air*, or *vital air*, or *oxygen air*; the *phlogiſticated air*, or *gas azote*; the *fixed air*, or *carbonic acid* *gas*; the *inflammable air*, or *hydrogen gas*; the *nitrous gas*, &c. But as of all the different airs five only appear to be applicable to the human body, *viz.* the common, the oxygen, the azotic, the carbonic acid, and the hydrogen airs, we ſhall not therefore extend our notice to any other ſort of elaſtic fluid; nor ſhall we deſcribe more than the principal properties of thoſe five; *viz.* ſuch properties only as may be uſeful to elucidate their action on the human body.

Of the Common, or Atmoſpherical Air.

THAT inviſible elaſtic fluid, which ſurrounds the earth, and in which we live, is indiſpenſably neceſſary to animal life, to combuſtion, and to other proceſſes. No animal can live, nor can any combuſtible body burn, without air. For either purpoſe the atmoſpherical air is more or leſs uſeful in proportion to its purity.

WHEN common air is mixed with another particular ſort of air, called *nitrous gas*, a diminution of bulk takes place, which is proportionate to the purity of the air; the pureſt air being diminiſhed moſt, and *vice verſa*; ſo that very impure air ſuffers no diminution. Hence the quality or goodneſs of common air may be aſcertained by mixing a certain quantity of it with a determinate quantity of nitrous air, and then meaſuring the diminution of bulk that enſues. The inſtrument in which this operation for aſcertaining the purity of the air is made, has been called an *eudiometer*.

THE purity of common air is not the ſame in all places, nor is it conſtant in the ſame place at all times. The variation in the latter caſe is much more conſiderable than in the former; yet, upon the whole, it is not very great. If in the uſual ſtate of the atmoſphere, and in places that are reckoned healthy, 100 parts or meaſures of common air be mixed with an equal quantity of nitrous air, their bulk, after the mixture, will be found, inſtead of 200 parts, to be between 100 and 120, more or leſs, according to the time of the year, ſituation of the place, ſtate of the atmoſphere, &c.

But in caves, mines, crowded rooms, hoſpitals, work-ſhops, and the like, the air is leſs pure; yet even in this caſe the difference, as indicated by the teſt of nitrous air, is but trifling; excepting indeed thoſe places in which the communication with the external air is abſolutely or almoſt entirely interrupted *.

NOTWITHSTANDING the ſmall difference which is manifeſted by this method of trying the purity of common air, it is however evident, from the oppreſſion which is felt in certain inſtances, and the reviving effect which is experienced in other caſes,

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* Dr. Prieſtley having dined one day in company with eight or ten perſons, in a large and very lofty room, and happening to go out of the room for a ſhort time, was, on his return, ſtruck with the offenſiveneſs of the air, and his curioſity prompted him to aſcertain the degree in which the air was injured. On trial he found that 100 parts of that air, with 100 parts of nitrous air, were reduced to 131 parts; whereas the like experiment being performed with the air of a well-ventilated room of the ſame houſe, the 200 parts of mixt aerial fluid were reduced to 125 parts.

that the human lungs are ſenſibly affected by the ſmalleſt differences in the purity of the air. But it is neceſſary to remark, that noxious particles are frequently ſuſpended in common air, which do not alter the effect of nitrous gas upon it, though, at the ſame time, they render it very offenſive to animals.

CONSIDERING the variety of vapours, minute bodies, &c. that are continually ſcattered through, and float in, the air, the atmoſphere muſt be looked upon as being always contaminated by the preſence of minute animal, vegetable, and even mineral, particles;—of bodies, in ſhort, that are foreign to, or unconnected with, the nature of air.

THE quality of common air is not altered by merely heating or cooling *, or by

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* Every degree of Fahrenheit's thermometer rarifies or increaſes the bulk of common air, by about $\frac{1}{473}$ part of the whole.

keeping, or by being for a time loaded with the vapour of water, nor by rarefaction or condenſation; but it is contaminated principally by reſpiration, by combuſtion, by the fermentation and putrefaction of animal and vegetable bodies, by the calcination of metallic ſubſtances, by the preſence of vegetables when they are not under the influence of the ſun's rays, and by the admixture of every other gas, or permanently elaſtic fluid, except the oxygen.

WHEN the common air is completely contaminated, or rendered unfit for combuſtion and reſpiration, it is (according to the preſent nomenclature) called *gas azote*, whereas it was formerly called *phlogiſticated air*.

VITIATED air is capable of being meliorated various ways, and the methods of effecting it may be diſtinguiſhed into natural and artificial. The natural means are far from being known to their full extent; but the vegetation of plants, in certain circumſtances,

cumſtances, and the contact of water, as in rains, dews, &c. are two very powerful correctors of contaminated air. Whether thoſe and other natural means, are ſufficient to preſerve the atmoſpherical air nearly in the ſame degree of purity, or whether that degree be conſtantly undergoing a gradual change, ſo as to render the air either continually better or worſe, is a very intereſting queſtion, but it can only be anſwered by the philoſophers of future generations. For my part, I am led to ſuſpect that the purity of the air is ſubject to a periodical fluctuation, or to an alternate increaſe and decreaſe for an uncertain number of years.

VENTILATION, and whatever promotes ventilation, does nothing more than remove vitiated air from thoſe places in which it is generated, and diſperſe it through the atmoſphere.

THE artificial methods of correcting vitiated air are few and imperfect. Ventilation, by means of bellows and other machines, is the moſt efficacious, and at the ſame time the moſt practicable way of improving the air of hoſpitals, ſick rooms, priſons, &c. *viz.* by removing the vitiated, and introducing a freſh current of purer air. A fire purifies the air of certain places, only by promoting the ventilation or circulation, and by drying the moiſture; but the air which has paſſed through the fire muſt not remain in thoſe places, otherwiſe the injury will be infinitely greater than the advantage. It has been confidently aſſerted, and denied, but it is now with limitation believed, that the vapours of nitrous, or of marine acid, will diveſt common air of the poiſonous effluvia of contagious diſorders; hence the vapours of thoſe acids are now frequently diſperſed through the air of hoſpitals, crowded ſhips, &c. When noxious vapours are merely ſuſpended in the air, as it often takes place in ſeveral natural and artificial proceſſes, then reſt alone, or at moſt a ſlight agitation in water will be ſufficient to purify the air. By the admixture of oxygen gas, a quantity of common air may be improved to almoſt any degree; but the method is difficult and expenſive; hence it can only be uſed with limitation in certain caſes, which will be ſpecified in the ſequel.

Of the Dephlogiſticated, or Oxygen Air.

THE oxygen is a ſort of aerial fluid, that poſſeſſes the uſeful properties of common air in a much more eminent degree; *viz.* it aſſiſts combuſtion and animal reſpiration for a much longer time, and with ſuperior energy. When a lighted candle is introduced into a veſſel full of oxygen air, its flame becomes larger, and ſurpriſingly brighter than in common air. Its heat is likewiſe increaſed to a very great degree.

THIS air is not found pure or unmixed in nature, but it may be extracted from various ſubſtances by means of artificial proceſſes. The leaves of plants, indeed, yield a conſiderable quantity of it whilſt they are expoſed to the light of the ſun; but the oxygen air which is thus produced, mixes with, and is diſperſed through the circumambient air as ſoon as it is generated; ſo that the air contiguous to the plants is ſeldom ſenſibly better than that of the neighbouring country.

BY the addition of nitrous air the oxygen is diminiſhed much more than common air. When 100 parts of good oxygen air are mixed with an equal quantity, *viz.* 100 parts, of nitrous air, their joined bulk will not exceed 50 parts, the other 150 parts having loſt the aerial form. Nor is this the utmoſt degree of diminution that can be produced; for if 100 parts of the pureſt oxygen that can be procured, be mixed with twice its quantity of nitrous gas, almoſt the whole bulk of elaſtic fluid will diſappear; at moſt, the reſiduum will not exceed five or ſix parts. By putting a lighted candle into a veſſel full of any ſpecies of reſpirable air, and obſerving the effect of that air on the flame, one may eſtimate the degree of its purity near enough for ſeveral purpoſes.

THE following are the principal methods of procuring this air. The green leaves of vegetables, when placed in a glaſs receiver full of, and inverted in ſpring water, and thus expoſed to the direct rays of the ſun, yield a conſiderable quantity of oxygen air, which aſcends to the upper part of the receiver, and may be eaſily removed from it for uſe. One hundred leaves of Indian creſs, *naſturtium Indicum*, in a gallon of ſpring water, will, in about three hours expoſure to the ſun, yield about ten cubic inches of oxygen air, not indeed quite pure, but yet vaſtly better than common air. I do not know of any plant whoſe leaves produce this ſort of air in greater abundance.

THERE are ſeveral ſubſtances from which oxygen air may be extracted by the action of heat or of acids; but thoſe which upon the whole yield it in greateſt plenty, and are fit to be uſed, are ſaltpetre or nitre, and the metallic calces.

ONE ounce of nitre, by remaining expoſed to a full red, or rather a white, heat in an earthen retort for about four or five hours, will give between 700 and 800 cubic inches of oxygen air, which is not equally good in every period of the proceſs, but at a medium it is ſuch that if 100 parts of it be mixed with 150 parts of nitrous air, the whole will be reduced to about 100 parts. This oxygen gas contains a quantity of nitrous acid in the form of vapour, and therefore, when it is to be uſed for reſpiration, the acid vapour muſt be previouſly ſeparated from it, which may be done by agitating the air in an alkaline lixivium, or at leaſt in lime water.

IF an ounce of *mercurius precipitatus per ſe* be expoſed to a barely red heat in a glaſs veſſel, it will yield at leaſt 66 cubic inches of very good oxygen air.

RED precipitate of mercury, when treated in the like manner, does alſo yield a conſiderable quantity of this ſort of air.

THE action of a red heat alone, or of vitriolic acid and a moderate degree of heat, expels from minium, or red lead, about ten or twelve times its bulk of oxygen, mixed with about one third of carbonic acid, air; the latter of which may be ſeparated from the former by waſhing in lime water. If the red lead be previouſly moiſtened with nitrous acid, and then ſtrong vitriolic acid be poured upon it, a greater quantity of oxygen gas will be obtained in a ſhorter time, and even without the application of heat.

THIS ſort of elaſtic fluid may be alſo obtained in ſmall quantities from ſeveral other metallic calces; but the mineral called *manganeſe*, gives a great quantity of it in an eaſy manner; it is at the ſame time a very cheap article, ſo that, upon the whole, manganeſe is at preſent the moſt eligible ſubſtance for the purpoſe of procuring oxygen air.

MANGANESE is not always of the ſame quality, and of courſe the elaſtic fluid, which is extracted from a given quantity of it, is variable both in quantity and quality. One ounce of good mangancſe, free from large calcareous particles, will, in a red heat, yield more than two pints and a half wine meaſure, or about eighty cubic inches of elaſtic fluid, about one tenth of which is carbonic acid, and the reſt is oxygen gas. By means of vitriolic acid and a gentle heat, about an equal quantity of elaſtic fluid, nearly of the ſame quality, may be extracted from manganeſe; but in this caſe ſome acid vapours come over with it, which muſt be carefully waſhed off in order to render the oxygen air fit for reſpiration.

THE oxygen air is diminiſhed to a much greater degree than common air, not only by the admixture of nitrous gas, but alſo by all the proceſſes which are known to diminiſh atmoſpherical air; and indeed ſometimes the whole quantity of oxygen air is abſorbed or deprived of its aerial form. Thus, by reſpiration, this air will be entirely abſorbed, excepting indeed that part which is converted into fixed air.

Of Fixed Air, or the Carbonic Acid Gas.

THIS gas, which is the heavieſt of the aerial fluids, is of an acid nature, but it reddens only light blue vegetable colours; it cryſtallizes with fixed alkali, and is poſſeſſed of a conſiderable antiſeptic power. It is abſolutely incapable of aſſiſting reſpiration and combuſtion*; nor is it diminiſhed by nitrous air. It combines with various ſubſtances, and is readily abſorbed by water, to which it communicates an acidolous taſte and ſparkling property. It is alſo abſorbed by, and precipitates the calcareous earth in lime water, but when in greater quantity, it again diſſolves the cal-

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[*] Even a mixture of one part of fixed, and eight parts of common, air will extinguiſh the flame of a candle. See Cavendiſh's paper, in the Phil. Tranſ. for 1766.

careous earth in the water. It alſo diſſolves iron in water, and keeps it diſſolved therein.

THIS elaſtic fluid is produced in a great many natural as well as artificial proceſſes. It is frequently found in ſubterranean places, eſpecially in the vicinity of volcanos, and hot ſprings, where, on account of its great ſpecific gravity, it remains for a conſiderable time, unleſs it be removed by means of ventilation, &c. It is contained more or leſs in almoſt all the mineral waters; it is abundantly produced in vinous fermentation. Reſpiration, combuſtion, and ſome other proceſſes, do likewiſe produce a certain quantity of carbonic acid gas. It is contained in a variety of mineral ſubſtances, and particularly in calcareous earth, as chalk, marble, &c. from which ſubſtances a great quantity of that gas may be extracted by means of heat or of acids *; the calcareous

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* The fixed air which is contained in white marble amounts to about one third part of its weight.

bodies remaining, after the loſs of that gas, in a cauſtic or acrid ſtate; ſo that the calcareous earth, by being in a mild ſtate whilſt it contains that elaſtic fluid, may be juſtly conſidered as a neutral ſalt, conſiſting of an earthy baſis and an aerial acid.

Of the Inflammable Air, or Hydrogen Gas.

INFLAMMABLE Air is the lighteſt of the elaſtic fluids. It is, as its name imports, a combuſtible fluid, which, like other combuſtible ſubſtances, may be inflamed by the contact of an ignited body, and will burn only when in contact with common, or oxygen, air.

THOUGH this ſort of elaſtic fluid be abſolutely unfit for reſpiration, it is not, however, ſo noxious as the carbonic acid. It ſuffers no diminution when mixed with nitrous air. Its bulk is increaſed of $\frac{1}{400}$ part of the whole by each degree of Fahrenheit's thermometer.

HYDROGEN gas is abundantly produced during the diſſolution of animal and vegetable bodies; hence it is often found to come out of ponds, burying grounds, and other places that contain animal and vegetable matter in a ſtate of decay. This gas does alſo frequently come out of the earth, where inflammable minerals are contained, as in coal mines, and mines of ſulphureous metallic ores. But in all thoſe caſes the inflammable gas, by being much lighter than common air, aſcends to the upper regions of the atmoſphere as ſoon as it is produced, and leaves the air, adjacent to the ground, very little, if at all, infected, excepting in vaulted ſubterranean places, where, indeed, beſides its infecting the common air, it ſometimes takes fire and explodes, to the great danger of the miners.

By means of heat, or of acids, this gas may be obtained from almoſt all ſorts of bodies, whether they be vegetable, animal, or mineral. But the greateſt quantity of it may be extracted from iron, or from zinc,

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by means of diluted vitriolic acid; and likewiſe from iron, by paſſing the ſteam of boiling water over its ſurface, the iron being red hot. When charcoal is treated in the laſt-mentioned manner, it likewiſe yields abundance of a peculiar ſort of inflammable gas, called *hydrocarbonate*, which however is mixed with a conſiderable proportion of carbonic acid gas.

HYDROGEN gas has the property of diſſolving and holding in ſuſpenſion, for a longer or ſhorter time, a variety of ſubſtances, ſuch as iron, charcoal, ſulphur, phoſphorus, &c. from which circumſtance it acquires a variety of particular names as well as properties. Hence we hear of the *phoſphoric hydrogen gas*, or *phoſphuret* of *hydrogen*; of the *ſulphuric hydrogen gas*, or *ſulphuret* of *hydrogen*, &c.; hence alſo we find that the hydrogen gas is not always of the ſame ſpecific gravity, nor has it always the ſame ſmell.

IT has been obſerved, that the hydrogen gas ſometimes loſes its inflammability, and degenerates into azotic air. This change happens more frequently when the hydrogen gas is mixed with common air. The cauſe of this phenomenon has not yet been fully aſcertained.

FOR the ſake both of brevity and of perſpicuity I have omitted to mention the ſpecific gravities of the abovementioned elaſtic fluids in the preceding pages, and ſhall add them all together in the following table, which contains their ſpecific gravities as well as the abſolute weight of a cubic inch of each elaſtic fluid.

THE gravity of common air is conſiderably affected by the variations of heat, wind, purity, &c. ſo that its ſpecific gravity, compared with that of water, has ſometimes been known to be as one to ſix hundred and ſix, and at other times as one to nine hundred and thirty-one*. The gravities of other elaſtic fluids are likewiſe ſubject to the ſame variations. But the following table has been calculated for a mean and temperate ſtate of the air, viz. when its gravity is to that of water, as one to eight hundred, when the height of the barometer is 29,85 inches, and when Fahrenheit's thermometer is at 55°.

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* Muſſchenbroek, tom. II. §. 2059.

Names of the elaſtic Fluids.	*Their ſpecific Gravities.*	*Abſolute Weight of a Cubic Inch of each in Troy Grains.*
Common air	1	0,31648
Azotic gas, or common air completely diminiſhed by nitrous gas	0,948	0,3
Oxygen air	1,0427	0,33
Carbonic acid gas	1,5	0,475
The lighteſt hydrogen gas	0,0833	0,02637

CHAPTER II.

Facts concerning the Reſpiration of Common, and of Oxygen, Air.

THAT the whole maſs of air which ſurrounds the earth is called the atmoſphere, that this atmoſphere extends to a conſiderable but unknown diſtance above the ſurface of the earth, that it decreaſes in denſity as it recedes from the earth, that its motion is called wind, that it acts upon all other bodies by its temperature, its weight, and other qualities, that it abſorbs vapours, or keeps them ſuſpended, and ſuch other like properties of the atmoſpherical fluid, have been rendered ſo common by the preſent ſtate of knowledge and of polite education, as not to demand any particular elucidation in this work; we ſhall, therefore, proceed immediately to enumerate the phenomena which have been aſcertained relatively to the reſpiration of common air, upon which, as upon a ſolid baſis, we may afterwards eſtabliſh the theory and the practice of applying the factitious airs to the human lungs.

A CERTAIN quantity of air will ſupport animal life, or combuſtion, but for a limited time. If a lighted middle-ſized tallow candle be confined in a veſſel that holds one gallon of common air, the flame will, in a few ſeconds of time, begin to grow dim, and it will be extinguiſhed at the end of about one minute; after this, if another lighted candle be introduced into the ſame veſſel, its flame will be extinguiſhed immediately.

IF a man be confined in a veſſel that holds ten gallons of common air, he will begin to feel an oppreſſion, and a difficulty of reſpiration, at the end of eight or ten minutes; this difficulty will gradually increaſe, and at the end of about half an hour, reckoning from the beginning of his confinement, he will loſe his ſenſation, his motion, and, preſently after, his life. The ſame effect will take place with other animals, in a longer or ſhorter time, proportionably to their ſize, nature, and diſpoſition of body.

In the uſual way of breathing, when reſpiration is performed in a natural and eaſy manner, a full grown perſon conſumes about five cubic feet, or thirty gallons and a half, beer meaſure, of common air per hour.

A MAN generally performs one inſpiration and one expiration for every ſeven or eight pulſations of his arteries; therefore reckoning, at a mean, eighty pulſations per minute, a perſon may be ſaid to perform eleven or twelve inſpirations, and as many expirations, in a minute. But reſpiration is quickened by various cauſes; *viz.* by the quickening of the pulſe, by agitation of the body, by heat, by ſurpriſe, by diſeaſes of the lungs, by a rarefied atmoſphere, and by impure air. Thus when a man is confined in a certain quantity of air, his reſpiration is quickened in proportion as that quantity of air becomes contaminated; he alſo takes in and expels a greater quantity of air at a time, in order to compenſate for the want of purity. The ſame quickening of reſpiration takes place on high mountains, where the air is more rare than on the level of the ſea.

AT a medium, about 30 cubic inches of air are taken in at one inſpiration, and a quantity, nearly equal to it, is thrown out at every expiration; but a great deal of air remains in the lungs, wind-pipe, and mouth; ſo that by a violent expiration after a natural inſpiration, a double quantity, *viz.* ſixty cubic inches of air, may be expelled, and even then ſome air neceſſarily remains in the lungs, wind-pipe, and mouth.

THE air which has ſerved for one inſpiration is not thereby completely contaminated, but it may be reſpired again and again. 350 cubic inches of common air were confined in a bladder that was furniſhed with a wooden tube; this tube was applied to the mouth of a healthy middle-aged man, who, ſtopping his noſtrils, endeavoured to breathe that quantity of air as long as he poſſibly could. After having performed forty inſpirations, his ſtrength began to fail, and he was obliged to deſiſt.

OLD perſons, people of a bad habit of body, or labouring under diſeaſes, and ſuch as eat and drink immoderately, will contaminate the air much faſter than the healthy, the moderate, and the young.

IT has been aſſerted, that ſome human beings can live with a much ſmaller quantity of air than has been mentioned above, and that divers have ſometimes been known to remain under water ten or fifteen minutes, and even a longer time *. It has

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* See Beckman's Hiſtory of Inventions, article *Diving-Bell*; and Gmelin's Reiſe Durch Ruſsland, II, p. 199.

been likewiſe diſcuſſed, whether ſuch divers were enabled to remain ſo long under water, and without air, by any particular conformation of the internal parts of their bodies, or from long practice and particular artifices. But there are ſtrong reaſons for diſcrediting the above-mentioned aſſertions. The inaccurate way of reckoning the time in ſuch caſes, and the common fondneſs for the marvellous, are in general the foundation of ſuch extraordinary reports. Upon the whole, it will be found, that the moſt experienced diver can hardly remain without air longer than a minute and a half; but moſt perſons will begin to feel a degree of uneaſineſs in about half a minute's time.

THE air, which has been completely contaminated by reſpiration, is deleterious to other animals, though ſmall and young animals will live a ſhort time in it: it extinguiſhes flame, is diminiſhed very little by nitrous air, contains about one-thirtieth of carbonic acid gas, and is contracted in bulk, the diminution being various, but hardly ever exceeding one-fifth part of the original quantity.

THE deleterious quality of the air that has been contaminated by reſpiration is in great meaſure owing to the carbonic acid gas, which is formed in the proceſs of reſpiration; and it is for this reaſon that, when an animal is confined in a veſſel full of reſpirable air, he will be able to live longer in it when ſome lime-water is placed in the veſſel, than otherwiſe; becauſe the lime-water abſorbs the carbonic acid gas as ſoon as it is generated. An animal will likewiſe live longer in a veſſel full of air, when he is placed at the upper than at the lower part of the veſſel; becauſe in the former caſe the carbonic acid gas will, on account of its great ſpecific gravity, fall towards the lower part of the veſſel, and will, of courſe, be at a diſtance from the body of the animal.

THE reſpiration of oxygen air is attended with peculiar phenomena. The oxygen, like the common, air, is diminiſhed by reſpiration; but the diminution proceeds to a much greater degree, for almoſt the whole quantity of elaſtic fluid will be reduced to a ſmall proportion of carbonic acid gas; and if the experiment be performed on lime-water, the whole quantity of oxygen air will diſappear. By repeatedly performing the experiment in this manner, it has been found that a healthy middle-aged man will entirely conſume two gallons of pure oxygen air in about five minutes time *. But in this caſe the oxygen air is conſumed faſter than is neceſſary for the uſual ſupport of life; and, in fact, if the ſame quantity of it be mixed with an equal quantity of azotic

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* Amongſt the various ways of producing oxygen air, it frequently happens, as we have already hinted, that acid vapours, or other volatile ſubſtances, are mixed with it; and in that caſe the animal which is confined in it may feel an oppreſſion on his lungs, or he may even be ſuffocated, when, by the teſt of nitrous gas, that air will actually appear to be much better than common air.

gas, it will then laſt as long again, *viz.* about ten minutes. It is therefore evident, that as the azotic gas is abſolutely incapable of aſſiſting reſpiration, the mixing of it with the oxygen air produces no other effect than that of preſenting a ſmaller quantity of oxygen to the ſurface of the lungs in each inſpiration. It is for the ſame reaſon that oxygen air is conſumed faſter, and that common air is vitiated ſooner, when reſpired under an increaſed, and ſlower when reſpired under a diminiſhed atmoſpherical preſſure.

THE air which is expelled from the lungs after every inſpiration, whether it be oxygen or atmoſpherical air, contains, beſides the portion of carbonic acid gas, a conſiderable quantity of aqueous vapour, which, in cold weather, is manifeſted by its condenſation as ſoon as it comes out of the mouth; for air can hold in ſolution a much greater quantity of water when hot than when cold.

THE breathing of pure oxygen air is generally, if not always, attended with an increaſe of heat, eſpecially about the lungs, and a quickening of the pulſe; but on ſome individuals thoſe effects are increaſed to ſuch a degree as to produce fevers, inflammation of the lungs, and even conſumptions, whilſt with other individuals they are moderate, temporary, and even ſalutary. But I ſhall endeavour to impreſs the reader's mind with a clearer idea of thoſe phenomena, by ſubjoining a ſhort account of the principal experiments that have been performed relatively to this intereſting part of our ſubject.

Dr. PRIESTLEY is, as far as I know, the firſt perſon who had the curioſity of breathing oxygen air. " I have," *ſays he*, " gratified that curioſity, by breathing it, " drawing it through a glaſs-ſyphon, and " by this means I reduced a large jar full " of it to the ſtandard of common air. The " feeling of it to my lungs, was not ſen" ſibly different from that of common air,

" but I fancied that my breaſt felt peculi-
" arly light and eaſy for ſome time after-
" wards *."

THE following experiment was performed, with great accuracy, before a philoſophical ſociety of gentlemen, at Dr. Higgin's houſe, in the year 1794.—Nineteen pints of pure oxygen gas were put into a receiver which ſtood inverted in lime-water. A tube proceeded from the upper part of the receiver to the mouth of the experimenter, a healthy man of about twenty-two years of age, who, after having accurately ſtopped his noſtrils, and having expired as much air from his lungs as he poſſibly could in a bent poſture of the body, took the end of the tube in his mouth, and began to breathe the oxygen air in a natural and ſlow manner, during which the receiver was permitted to play freely up and down in the lime-water, in order to prevent any increaſe or decreaſe of

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* Experiments on Air, &c. vol. ii. p. 102.

preſſure on the lungs. An aſſiſtant was employed to keep the lime-water in continual agitation, in order to promote the abſorption of the carbonic acid air that was formed in the courſe of the experiment. The bulk of oxygen air was viſibly diminiſhed at every inſpiration, and the lime-water became turbid. The whole of the oxygen air was conſumed in ſix minutes time, and the experimenter ſtopped only when the lime-water came to his mouth. "During the reſpiration his pulſe (which, "previous to the experiment, was only "ſixty-four) quickened to ninety beats in a "minute, and was conſiderably increaſed "in fulneſs and ſtrength; but he felt no "inconvenience whatever.

"THE veſſel being immediately charged "again with nineteen pints of gas, he re-"ſpired theſe alſo, and conſumed them en-"tirely in ſix minutes. His pulſe was in-"creaſed to 120 beats in a minute, and "was vigorous withal. He felt no in-"convenience, but had a ſenſe of unuſual

" warmth in his lungs. In one hour after " the experiment his pulſe returned to " ſixty-four *."

DR. BEDDOES found the breathing of oxygen air extremely hurtful. " To my own " lungs," *ſays he*, " it feels like ardent ſpi" rit applied to the palate; and I have " often thought I could not ſurvive the in" ſpiration of oxygen air, as it is driven " from manganeſe by heat, many mi" nutes †."

A SINGLE inſpiration of oxygen air may be kept in the lungs much longer than an inſpiration of common air.

WHEN oxygen air is mixed with common air, and is then breathed in that diluted ſtate, the lungs are leſs affected with

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[*] Minutes of the Society for Philoſophical Experiments and Converſations, page 146.

[†] Conſiderations on the Medicinal Uſe of Factitious Airs, vol. i. p. 14.

the ſenſation of heat, nor is the pulſe quickened ſo much as when pure oxygen is uſed; yet in this diluted ſtate the oxygen air has been found beneficial in a variety of caſes, which will be mentioned in the ſequel. We ſhall likewiſe mention the proportion of the two elaſtic fluids, which has been found to anſwer beſt for each particular caſe; but in the preſent chapter it will be neceſſary to ſtate the effect which the breathing, or the action, of oxygen air has been obſerved to have upon particular parts of the animal body, whence proper conjectures may be formed of its general uſe in the animal economy, and of its application for the cure or alleviation of particular diſorders.

THAT oxygen air is a powerful ſtimulus to the lungs, has been evinced by various experiments, but by none better than the following, which has been repeated with equal ſucceſs by different perſons:—Some young rabbits were kept under water till every appearance of life, and even a hope of recovery, had vaniſhed; they were then withdrawn, and oxygen air was forced through the mouths of ſome of them into their lungs, whilſt a ſimilar operation with common air was performed on the others: the latter remained dead, whilſt the former recovered. Young dogs and kittens were ſubjected to the like experiment, the general reſult of which was, that the oxygen air brought them to life where common air proved ineffectual. Animals thus apparently deprived of life have frequently revived by only being placed in a veſſel full of oxygen air, without forcing it into their lungs. From this fact we derive a powerful method of reſtoring ſuſpended animation.

RABBITS, dogs, kittens, and birds, have been often confined in veſſels full of oxygen air, and have been ſuffered to remain in that quantity of air for various lengths of time. It has been conſtantly obſerved, that they live longer in that, than in an equal quantity of common air. But whenever the experiment has been protracted to a certain length, it has almoſt always been attended with illneſs, with a ſtrong inflammation, and even with death. The diſſection of the animals that have been thus *oxygenated*, has principally exhibited the following phænomena:

THE lungs appear of a florid red colour, often marked on the edges with ſigns of mortification; the heart appears of a florid red colour; the pleura is generally inflamed; the colour of the liver, kidneys, and the blood-veſſels of the meſentery, is more inclining to red than is otherwiſe known to be; their blood coagulates ſooner; their muſcles are more vigorous, and ſhew ſigns of ſtronger irritability.

ANIMALS that have breathed oxygen air, previouſly to their being immerſed in water, will not die ſo ſoon as thoſe which have breathed common air only. The quantity of purer air, which remains in the lungs of the former, is what in great meaſure, if not entirely, contributes to the preſervation of their lives.

AFTER having deſcribed, in the preceding paragraphs, the principal phænomena, which are produced by the reſpiration of pure, or nearly pure, oxygen air, it will be hardly neceſſary to add, that a mixture of common and oxygen airs, or of azotic and oxygen airs, muſt produce phænomena analogous to thoſe which have been mentioned above, but nearly proportionate to the quantity of oxygen air which is contained in the mixture. There is, however, a remarkable circumſtance, which muſt be carefully attended to, as being of the utmoſt conſequence in the application of oxygen air to medicinal uſes. This circumſtance is, that whilſt the reſpiration of pure oxygen air, or of ſuch air as contains a great proportion of oxygen, is attended with inflammation and other bad conſequences, the reſpiration of common air a little improved by the admixture of a moderate proportion (as for inſtance, one-

15th, or even one-20th) of oxygen air, is attended with remarkably ſalutary effects.

THE inhalation of ſuch diluted oxygen air, or we may call it improved atmoſpherical air, for about 10 or 15 minutes a day, has been found to produce a florid colour in the face, to conciliate ſleep, to ſtrengthen the organs of digeſtion, to promote circulation, to ſtrengthen the pulſe, &c.

HOWEVER ſtrange and unaccountable thoſe effects may at firſt ſight appear, eſpecially to thoſe who are not converſant in philoſophical inveſtigations, the facts are certainly true, and a ſimple reflection may contribute to diſſipate the wonder; namely, that people of all deſcriptions, but eſpecially ſuch as are weak and emaciated, derive a conſiderable degree of exhilaration and improvement by a ſhort excurſion out of a town, or of a houſe, when the ſuperior purity of the country air, above that of the town, is not equal to that which is produced by mixing common air with even one-twentieth of its bulk of oxygen air. But we ſhall have occaſion to notice this circumſtance again in the ſequel.

CHAPTER III.

Phænomena ariſing from breathing other aerial Fluids, beſides the Common and the Oxygen Airs.

IT has already been noticed, that of the various ſorts of elaſtic fluids, two only, *viz.* the common and the oxygen airs, are capable of aſſiſting reſpiration, from which it may be naturally deduced, that by the admixture of any other gas, either of thoſe two will be rendered leſs reſpirable in different degrees. But this diminiſhed goodneſs of the reſpirable airs, this mixture of reſpirable and unreſpirable aerial fluids, has proved beneficial in a variety of medical caſes; hence many experiments have been made for the purpoſe of aſcertaining the mixtures that are more applicable to any particular caſe, and likewiſe the phænomena which ariſe from the reſpiration of thoſe mixed gaſſes.

I WOULD not be underſtood to aſſert or think that the action of the unreſpirable gaſſes conſiſts merely in lowering the quality of common air, or of oxygen air; for that purpoſe could be more commodiouſly anſwered by breathing a certain quantity of common air longer than in the uſual way. The fact is, that, beſides rendering the common or oxygen air leſs reſpirable, each particular gas imparts peculiar and remarkable properties to the mixture, which mixtures are of courſe applicable to particular caſes. With reſpect to thoſe mixtures, much has already been aſcertained; but a great deal more remains to be examined and tried under a variety of circumſtances, to which object we muſt look forward with anxious expectation.

IT has been repeatedly aſſerted and denied, that pure and unmixed hydrogen, or inflammable gas, may be reſpired with impunity for a conſiderable time, and many experiments are related to prove each of thoſe contradictory aſſertions. The equivocal reſults of thoſe experiments ariſe from two cauſes, *viz.* from the variable nature of the gas, and from the different quantity of common air, which remains in the lungs, mouth, &c. of the animals that are ſubjected to ſuch experiments.

INFLAMMABLE gas, in the common way of producing it, is ſeldom very pure; but even when that is the caſe, its coming into contact with the lungs is naturally prevented by the common air, which remains in that organ previouſly to the application of the inflammable gas, the latter being much lighter than the former. By a ſtrong expiration in a bent poſture of the body, the common air may, in great meaſure, be expelled; but even in that caſe a certain quantity of it unavoidably remains in the mouth, wind-pipe, &c.

OF the different ſorts of inflammable gas, that which is obtained by paſſing the ſteam of water over red hot iron ſeems to be the leaſt offenſive. Next to this is the gas which is obtained from iron and diluted vitriolic acid. The other ſpecies are more variable in their quality; but they are all incapable of aſſiſting reſpiration; and if a perſon will carefully expel as much air from his lungs as he poſſibly can by a forced expiration in a bent poſture, and will then apply his mouth to a veſſel, or to a tube that communicates with a veſſel, full of pure inflammable gas, keeping his noſtrils ſtopped at the ſame time, he will find, after about three or four inſpirations, that the florid colour of his face is vaniſhed, and his ſtrength is ſo far diminiſhed as to prevent the proſecution of the experiment. Having myſelf been more than once witneſs to this experiment, I have always obſerved an evident change of colour in the face of the experimenter after the ſecond inſpiration.—The gas had been extracted from iron and diluted vitriolic acid.

INFLAMMABLE gas may be rendered leſs noxious by agitation in water.

WHEN this gas (meaning that which is obtained from the vapour of water and red hot iron, or from iron and diluted vitriolic acid) is mixed with about an equal quantity, or even a ſmaller proportion of common air, it may then be breathed with ſafety for a conſiderable time; and it is remarkable, that the lungs are affected by it with a peculiar ſenſation of levity. This ſingular property has rendered it uſeful and beneficial in inflammations of the lungs, convulſive coughs, &c. where the object is to diminiſh the irritability of the parts affected. During this operation the face will be found to grow dark or livid, but the natural colour will be ſpeedily recovered by afterwards breathing the common air in the uſual way.

THE hydrocarbonate, *viz.* that ſpecies of inflammable gas which is produced by paſſing the ſteam of water over the ſurface of red hot charcoal, is much more pernicious to the lungs. Animals will die much ſooner in this than in the above-mentioned ſpecies of inflammable gas. Sometimes two or three inſpirations of pure hydrocarbonate are ſufficient to occaſion the death of the animal.

THE active quality of this gas is perceivable even when diluted with 20 or 30 times its own bulk of common air. A perſon who breathes it in that diluted ſtate for about a quarter of an hour, is generally made ſick and vertiginous; feeling at the ſame time a ſenſation of cold throughout his whole body; his lips become blue, the face livid, and the pulſe feeble, though frequent; but the ſenſibility of the lungs is conſiderably diminiſhed by it, on which account it has been adminiſtered in various caſes with advantage to the patient. Some patients, after the reſpiration of this diluted gas, have experienced ſuch levity or inſenſibility about the region of the lungs, as to remain for a time entirely free from pain.

IT is remarkable, that the ſickneſs, dizzineſs, or, in ſhort, the bad effects of the diluted hydrocarbonate, frequently come on after the operation, and ſometimes come on and go off two or three times repeatedly, at the interval of an hour or longer; which ſhews that this ſort of gas can hardly be adminiſtered with too much care and caution.

PURE carbonic acid gas is likewiſe very pernicious to the lungs. Sometimes one or two inſpirations of it have been quite ſufficient to kill an animal; and, indeed, animals will die in carbonic acid gas, and likewiſe in hydrocarbonate, much ſooner than if they did not reſpire at all, or if they were immerſed in water, which proves that ſome noxious principle is introduced by thoſe gaſſes into the body.

OF the animals, thoſe which have large lungs in proportion to their bulk, and are formed to live in the air, are ſooner affected by this gas; thus the birds have in general been found to die ſooneſt in carbonic acid air; the dogs come next, then the cats, then the amphibious animals, and laſtly, the inſects *. If they are not left too long in this gas, they will, in general, revive, by being removed into the common air. When they die in it they ſhew no ſtruggles. By being frequently expoſed to this gas, the animals may be ſo habituated as not to be killed by it ſo ſoon as others that were never expoſed to it.

THE following are the appearances which have been more commonly obſerved on the diſſected bodies of the animals that have been killed by carbonic acid gas.—The lungs are a little collapſed, ſhewing a few

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* Bergman *de Acido Aereo*, ſect. 26.

inflamed places. The right ventricle and right auricle of the heart, the pulmonary artery, the *vena cava*, the jugulars, and the veſſels of the brain, are turgid with blood; but the pulmonary veins, the *aorta*, the left ventricle, and left auricle of the heart, are moſtly flaccid. The muſcular fibres of the body are found deprived of irritability, ſo that even the heart, extracted whilſt the body is ſtill warm, ſhews no ſigns of irritability *.

FISHES die in a few minutes time, in water impregnated with carbonic acid gas †.

WHEN this gas is diluted with twice or three times its own bulk of common air, it may then be breathed for a certain time, but not nearly ſo long as the mild ſorts of inflammable air ſimilarly diluted.

PURE azotic gas is about as deleterious as the inflammable gas from iron and diluted vitriolic acid; yet the animals that are confined in it until they appear to be dead, will, on being withdrawn, recover more frequently than thoſe which are confined in the inflammable gas.

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* Bergman *de Acido Aereo*, ſect. 26.

† Prieſtley's Exp. and Obſerv. vol. ii. ſect. 13.

THE artificial gaſſes have likewiſe been breathed in combinations of three or four at a time, one of them always being either the common or the oxygen air; but it does not appear that thoſe triple or quadruple mixtures have been tried in a great variety of caſes.

IN the reſpiring of combined gaſſes, due regard muſt be had to their ſpecific gravities, as this circumſtance is often the cauſe of phænomena that are erroneouſly attributed to other ſources. The difference between the ſpecific gravities of the common, the oxygen, and the azotic, airs, is indeed trifling; but the inflammable and the carbonic acid gaſſes differ conſiderably from the reſt, and eſpecially from each other; the former being a great deal lighter, and the latter much heavier, than common air. If the inflammable, the carbonic acid, and the common or the oxygen, airs, be not well mixed together in a veſſel, they will remain ſeparate for a conſiderable time in their reſpective places, *viz.* the carbonic acid air in the loweſt part, the common in the middle, and the inflammable in the higheſt part of the veſſel; but even when they are well mixed together, they always ſhew a tendency to ſeparate, ſo that after a ſhort interval each of them will be found leſs mixed in its reſpective place.

IT is hardly neceſſary to add, that the ſame peculiarity of ſituation muſt alſo take place within the lungs, and that this is, perhaps, the ſole cauſe which renders the carbonic acid gas more noxious than the inflammable gas, and the heavy ſort of inflammable gas, *hydrocarbonate*, more offenſive than the lighter ſpecies of it.

CHAPTER IV.

Phænomena ariſing from the Application of the abovementioned elaſtic Fluids to other Parts of the Animal Body beſides the Lungs.

IT has been found that the pores of the ſkin imbibe and expel a ſmall quantity of air, and it is ſaid, that in equal times they will abſorb a much greater quantity of oxygen, than of common, or of any other, air.

DIFFERENT ſorts of elaſtic fluid were ſeparately injected into the cellular membrane of animals, through inciſions made in the ſkin, and the apertures were cloſed immediately after. The appearances, as obſerved by Dr. Maxwell *, and confirmed by others, were in general as follows:

* See his Theſis, Edinburgh, 1787.

COMMON air ſwelled or puffed the animal, rendered it uneaſy for a day or two, after which the ſwelling began to decreaſe, and vaniſhed entirely at the end of about three weeks.

OXYGEN air ſwelled the animal, and rendered it ſomewhat uneaſy for a ſhort time; the uneaſineſs, however, ſoon vaniſhed, the animal became unuſually lively, and the ſwelling diſappeared much ſooner than in the caſe where common air had been uſed.

AZOTIC gas ſwelled the animal, and rendered it dull, by ſuperinducing a ſort of ſtupor, which, in a few days time, degenerated into convulſions, and at laſt killed the animal.

CARBONIC acid gas was rapidly abſorbed, and ſeldom produced any ſlight and temporary uneaſineſs.

HYDROGEN gas ſwelled the animal, produced heavineſs and ſhiverings; but the ſwelling diſappeared ſooner than in the caſe of common air.

MR. GIRTANTER is ſaid to have injected azotic gas into the jugular vein of a dog, in conſequence of which the animal died at the end of twenty ſeconds. On opening its thorax, the pericardium, and the heart, the right auricle and right ventricle were filled with black blood; the left ventricle was of its ordinary dark colour; the heart and muſcles had loſt their irritability almoſt entirely. A ſimilar experiment being made with carbonic acid gas, inſtead of azotic gas, nearly the ſame phænomena took place.

BLOOD recently taken from the veins of an animal, and expoſed to the common air, becomes of a bright red colour; and if expoſed to oxygen air, its colour will become ſtill brighter, and the oxygen air will be diminiſhed, and partly converted into carbonic acid air. On the contrary, if the blood thus brightened, or the blood taken from the arteries of an animal, which is well known to be of a florid red, be expoſed to any of the unreſpirable gaſſes, its colour will be darkened preſently, and a ſmall part of the elaſtic fluid will be abſorbed. It is to be remarked, that thoſe effects take place even when an animal membrane, as a piece of bladder, intervenes between the blood and the reſpirable or unreſpirable elaſtic fluids *. Even the colour of the fleſhy parts is made to incline more towards a florid red by the action of oxygen air.

That the oxygen air acts as a ſtimulus on other parts of the body, as well as on the lungs, is clearly proved by the following often repeated experiment: A bliſter being formed on the hand, or a finger, by the application of the uſual plaiſter of cantharides, the ſkin was cut off, and the hand was immediately introduced into a veſſel full of oxygen air: the conſequence was, that the experimenter felt a very acute pain. The hand was then removed into a veſſel full of

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* Prieſtley's Exp. and Obſ. vol. III. ſect. 5.

carbonic acid gas, the action of which removed the pain in a very ſhort time. On the hand being expoſed to the common air, a degree of pain returned, and on being, as at firſt, placed in oxygen air, the pain became acute.

THE contact of inflammable gas does neither accelerate nor retard the putrefaction of animal matter.

WHEN the ſtream of carbonic acid air is iſſuing out of a ſmall aperture, as that of the tube of the phial in which this gas is uſually produced from calcareous earth and diluted vitriolic acid, if the mouth or noſtrils be preſented to it, they will be affected with a peculiar, and rather pleaſing, pungency.

THIS gas is poſſeſſed of conſiderable antiſeptic power. And for this property, it is adminiſtered to the animal body either internally or externally, and ſeparate parts of animal or vegetable ſubſtances may be preſerved in it for a conſiderable time.

IT is applied internally to the ſtomach, or externally, either in the aerial form, or combined with water and other ſubſtances. Many fluid or ſolid bodies derive their antiſeptic property from their containing this gas in conſiderable quantity; ſuch are liquors in a ſtate of vinous fermentation, ripe fruit, certain mineral waters, &c.

FRUIT may be preſerved ſeveral days longer in carbonic acid than in common air. This is alſo the caſe with animal fluids, or with pieces of meat that are not very large, but they are apt to looſe their flavour. Large pieces of meat are ſaid to have been preſerved for ſeveral days longer than in the uſual way, by only waſhing them three or four times a day in water ſtrongly impregnated with carbonic acid air.

DISTILLED water, or water that has been deprived of its air by boiling, will, in forty days time, and in a temperate atmoſphere, abſorb, without needing any agitation,

tion, about $\frac{1}{14}$th of its bulk of oxygen air, whereas of common air it will abſorb about the half of that quantity, *viz.* $\frac{1}{28}$th part. It will abſorb in a few hours time a quantity of carbonic acid gas little greater than its own bulk; but a cold temperature and an increaſed atmoſpherical preſſure will enable it to abſorb a much greater quantity of that gas. Of inflammable gas it will abſorb about as much as it does of common air, *viz.* $\frac{1}{14}$th part of its bulk.

THIS abſorption of elaſtic fluids by water is much expedited by agitation of the latter in the former.

CHAPTER V.

Theory of the Nature of Aerial Fluids, and of Reſpiration.

THAT reſpiration and life can not be maintained without atmoſpherical air, is a fact known to the philoſophers of the remoteſt antiquity; but their ideas of the uſe of air in reſpiration were vague, and unſupported by experiments. On the revival of learning in Europe, and eſpecially after the ſixteenth century, the ſcientific inquiries of philoſophers, phyſicians, and chemiſts, aſcertained that the air was ſubſervient to other natural as well as artificial proceſſes, beſides reſpiration; and likewiſe that there actually exiſted various ſpecies of air, ſome of which were highly noxious *. The progreſs and diſſemination of ſcience gradually added new articles to the ſtock of knowledge relative to the aerial fluids; but the great improvements, the ſurpriſing diſcoveries, which have produced a total revolution in this branch of natural philoſophy, were reſerved for the preſent age, and are undoubtedly due to the labours of modern philoſophers.

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* See the works of Van Helmont and Dr. Mayow.

IT is entertaining to peruſe the works of authors previous to the late diſcoveries, and to obſerve how near the ideas of ſome of them approached the modern theory of reſpiration. Hippocrates conſidered air as one of the aliments of the body. Dr. Mayow aſſerts, that ſome nitre, or aerial ſpirit of nitre, enters the body through the lungs, and furniſhes the animal ſpirits at the ſame time that it communicates heat to the blood*.

DR. WHITE ſuppoſed that the ſtimulating quality of the air is neceſſary to keep the heart in motion. Mr. Hewſon, obſerving that the blood has a more florid red appearance in the left, than in the right, auricle of the heart, concludes with ſaying, that as the change of colour in blood out of the body is occaſioned by the contact of air, ſo it may be preſumed that the ſame change within the body is occaſioned by air alſo, and that the change takes place in the lungs.

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* See his work, printed at Oxford in the year 1674, under the title of *Tractatus quinque Medico-Phyſici.*

DR. PRIESTLEY formed a very ingenious hypotheſis concerning the uſe of air in reſpiration, which he eſtabliſhed by a train of well-conducted experiments on the then prevailing phlogiſtic theory. The principal law of this hypotheſis is, that the air ſerves to abſorb the ſuperfluous phlogiſton from the blood through the lungs, and that the more or leſs florid redneſs of the blood depends on the different quantities of phlogiſton in it *. The phlogiſton, however, or principle of inflammability, is not

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* For a full explanation of this hypotheſis ſee the Doctor's Exper. and Obſ. vol. III. ſect. 5; or the Phil. Tranſ. vol. LXVI.; and likewiſe Dr. Crawford's work on Animal Heat and Inflammation.

a real, but a ſuppoſed, agent in nature, which, for want of better information, was applied to explain moſt of the phænomena of combuſtion, decompoſition, and (by Dr. Prieſtley's ingenuity) of reſpiration. But the preſent ſtate of knowledge being, in conſequence of very recent diſcoveries, ſufficient to account for the abovementioned phænomena in a ſimpler, and, of courſe, a more natural way, the ſuppoſition of the phlogiſtic principle is become altogether ſuperfluous.

OF this new or antiphlogiſtic theory, which may be ſeen at large in a variety of recent publications, and of the diſcoveries which gave riſe to it, I ſhall briefly mention ſuch particulars only, as may be of uſe in elucidating the action of the aerial fluids on the human body. As for the facts upon which its ſeveral parts are eſtabliſhed, and likewiſe for the objections which have been made to it, I muſt refer the reader to the works of other authors *.

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* See Lavoiſier's Elements of Chemiſtry, Dr. Prieſtley's pamphlet, entitled, Experiments and Obſervations relating to the Analyſis of Atmoſpherical Air, &c.; Fourcroy's Chemiſtry, &c.

THIS theory is at preſent almoſt univerſally adopted by perſons of the firſt rank in philoſophy, and daily experience is continually throwing new light upon it; yet it muſt be confeſſed that it is by no means free from doubts and difficulties. It is in conſequence of thoſe deficiencies, and on account of the uncertainty, which is inſeparable from the nature of hypotheſes, that I have carefully ſeparated the knowledge of facts from the ſuppoſition of their cauſes. The former have been arranged in the preceding four chapters, and any perſon may account for them in the manner he likes beſt; but it was deemed neceſſary, at the ſame time, to add the moſt ſatisfactory explanation which can be ſuggeſted by the preſent ſtate of knowledge, and this explanation will be found in the preſent chapter.

THE ſenſation of heat is ſuppoſed to be produced by a peculiar fluid called *the caloric*, or elementary heat; a fluid extremely fine, penetrating, and ſo light that its weight cannot

not be eſtimated. All ſorts of bodies are expanded by the addition, and contracted by the abſtraction of caloric. The acceſſion of it to the human body produces the ſenſation of heat, and the ſeparation of it produces the ſenſation of cold. Thus when we touch a ſubſtance which is of a lower temperature, viz. colder than our bodies, that ſubſtance, by robbing us of a portion of caloric, will excite the ſenſation of cold; and on the contrary, if the ſubſtance be hotter than our bodies, it will excite the ſenſation of heat, by adding caloric to our bodies.

WHEN a number of bodies of different temperatures are put together, the ſum of their quantities of caloric will be diſperſed amongſt them in ſuch a manner as to render them all of the ſame temperature, ſo that a thermometer will be found to indicate the ſame preciſe degree of heat in any one of them. But it muſt be remarked, that though the temperature be the ſame, yet the abovementioned ſum of elementary heat will not be divided equally amongſt the bodies, unleſs the bodies be of the ſame ſort, as, for inſtance, three or four parcels of water, or of mercury, &c.; but ſome bodies will imbibe more and others leſs of the caloric, in order to be raiſed to the ſame temperature, or apparent degree of heat; and this peculiar diſpoſition in any particular body is called its *capacity for containing* caloric. This property of bodies may be rendered more intelligible by an example or two. Suppoſe that a pint of water, at 100° of heat, be mixed with another pint of water at 200° of heat, the heat of the mixture will be nearly 150°, *viz.* an arithmetical mean between the two temperatures; but if a pint of water at 100° of heat be mixed with a pint of quickſilver at 50° of heat, the heat of the mixture will be found to be 80°, (*viz.* greater than 75°, which is the arithmetical mean) which ſhews that either the quickſilver or the water, has imbibed more than its equal ſhare of caloric, in order to have its temperature raiſed to the common degree of ſenſible heat. On the other hand, if the degrees of heat be reverſed, *viz.* the water at 50° be mixed with an equal bulk of quickſilver at 100°, the temperature of the mixture will be 70°, which plainly ſhews, that water abſorbs more heat than quickſilver; and as the difference between their original temperatures and the temperatures of the mixture in the firſt and laſt caſe is as two to three, we therefore ſay, that the abſolute heat of mercury is to that of an equal bulk of water as two to three; *viz.* "that the compa-"rative quantities of their *abſolute* heats "are reciprocally proportionable to the "changes which are produced in their "*ſenſible* heats, when they are mixed to-"gether at different temperatures *."

SIMILAR experiments performed on a variety of bodies ſhew, that unequal quantities of abſolute heat muſt be communicated to them in order to raiſe their temperature, or apparent heat to the ſame degree.

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* Dr. Crawford on Animal Heat and Inflammation; in which work a full explanation of the doctrine of heat will be found, together with a table of the comparative heats of different bodies.

IT is in conſequence of their various capacities, that whenever bodies of different ſpecies are brought together, a change of temperature is generally produced. Thus, if you mix ſpirit of wine and water, the mixture will become hotter than the ingredients were before. A much greater degree of heat will be produced by mixing water with vitriolic acid; and, on the other hand, if ſal ammoniac de diſſolved in water, a conſiderable degree of cold will be produced.

IN moſt ſubſtances a total change in their ſtate of exiſtence is produced by the ſuperaddition of caloric; thus water is gradually changed from its ſolid ſtate of ice, into a fluid, and then into an elaſtic fluid, called vapour, by the addition of different degrees of caloric. And it muſt be remarked, that this change of ſtate in bodies is attended with a change of capacity for containing caloric; the leſs denſe ſtate containing the greateſt quantity of caloric. Thus water in the fluid ſtate contains leſs caloric than when it is reduced into vapour, and more than when it exiſts in the form of ice.

THE aerial fluids are ſuppoſed to be combinations of certain ſubſtances with caloric. Oxygen air conſiſts of a ſubſtance, *ſui generis*, which is called oxygen, combined with caloric, and, in all probability, with the matter of light alſo.

AZOTIC gas conſiſts of a particular ſubſtance, called *azote*, and caloric. Common air conſiſts of azotic gas and oxygen air, in the proportion of 73 parts of the former to 27 of the latter. By a mixture of thoſe elaſtic fluids in the ſaid proportion, an aerial fluid is formed exactly like the atmoſpherical air *.

HYDROGEN gas conſiſts of a particular ſubſtance, called *hydrogen*, and caloric. As for the particular ſubſtances which are frequently found in the hydrogen gas, ſuch as phoſphorus, particles of iron, &c.; they muſt be conſidered as extraneous matters ſuſpended or diſſolved in the gas, but not eſſential to its conſtitution.

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* In general the atmoſpherical fluid contains a variety of extraneous particles, but they hardly ever exceed the hundredth part of the whole, and ſeldom amount to that quantity.

CARBONIC acid gas conſiſts of a peculiar ſubſtance, called *carbon*, or the conſtituent part of charcoal, and oxygen air, in the proportion of ſeven of the former to eighteen of the latter.

WATER, which has long been eſteemed an elementary ſubſtance, incapable of decompoſition, has been found to conſiſt of hydrogen gas and oxygen gas, in the proportion of three of the former to ſeventeen of the latter. By the combuſtion of thoſe elaſtic fluids water is actually formed; and, on the contrary, water may be reduced into thoſe aerial fluids, by placing it, under certain circumſtances, in contact with bodies that attract one of its components, or by the action of electricity *.

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* See Fourcroy's Chemiſtry, the third volume of my Electricity, and the Phil. Tranſ. for 1797, P. I.

COMBUSTION conſiſts in the abſorption of the baſe of oxygen air, *viz.* the oxygen, by bodies that are ſaid to be combuſtible, and ſetting free both the caloric and the light, which, as has been mentioned above, are the two other components of oxygen air. Agreeably to this definition, we muſt conſider as combuſtions not only the burning of coals and other fuel, as is uſually done in our chimneys, but alſo the calcination of metals, and reſpiration itſelf, ſince in both thoſe proceſſes an abſorption of oxygen, and an evolution of caloric, take place.

IF the calcination of a metal (which is now called *oxygenation* of the metal) is carried on ſlowly, as by merely expoſing certain metals to the atmoſphere, then the caloric and the light, which is ſeparated from the oxygen portion of the atmoſphere, is too little to affect our ſenſes, and we can only obſerve, after a certain time, that by having abſorbed a quantity of oxygen, the metallic ſubſtance has loſt its combuſtibility (*viz.* its attraction for oxygen) and has aſſumed a different appearance, together with an increaſe of weight. If the oxygenation be carried on in a quick manner, as when an iron wire is made very hot in oxygen air, then both the caloric and the light become manifeſt.

WHEN the metal has abſorbed as much oxygen as its nature admits of, it is then ſaid to be incombuſtible, or completely oxydated. But if by any means the oxygen be ſeparated from it, then the metallic oxyde will be converted again into a metallic ſubſtance ſuſceptible of combuſtion.

IN the combuſtion of animal and vegetable ſubſtances, which conſiſt of various component articles, the proceſs is accompanied with peculiar phænomena, which vary with the nature of the combuſtible, the quickneſs of the combuſtion, and other circumſtances. Thus in the burning of wood, the oxygen of the atmoſphere is abſorbed, the caloric and the light are diſengaged,

gaged, the carbon of the wood combines with a portion of the oxygen, and forms carbonic acid gas, the evolved caloric converts the aqueous part of the wood into ſteam, and ſo forth.

A VARIETY of phænomena may be obviouſly explained upon the baſis of this doctrine.

WE may eaſily comprehend why no ſort of combuſtion can take place where no oxygen air exiſts; as alſo why every ſort of combuſtion will proceed rapidly in pure oxygen air, and much leſs ſo in common air; for the latter contains only a ſmall proportion (*viz.* about one quarter) of oxygen air. Thus may other proceſſes be eaſily reconciled to, or explained by, this theory. But it is now time to examine the phænomena of reſpiration.

THE uſes of reſpiration are various and important. They may be divided into mechanical and chymical. Of the mechanical, ſuch as the voice, the cough, &c. no notice will be taken in this work. The other uſes principally conſiſt in furniſhing the body with a conſtant ſupply of oxygen, and probably in exonerating the blood of the ſuperfluous carbon and hydrogen.

IN the proceſs of reſpiration a decompoſition of the air takes place in the lungs. The blood, in its paſſage through that organ, abſorbs the oxygen of the common air, diſengages the caloric, and leaves the azotic gas, with a ſmall reſiduum of oxygen air. The blood, therefore, does not imbibe the oxygen air, but the oxygen alone, *viz.* the baſis of oxygen air, diveſted of that quantity of caloric which was neceſſary to give it the aerial form. The caloric which is ſet free in this proceſs, by diſperſing itſelf through the body, keeps up its temperature, and forms the origin of animal heat. However, this part of the theory which relates to the formation of animal heat, is embarraſſed with difficulties, which will be noticed preſently.

THE carbonic acid gas, which is formed in the proceſs of reſpiration, is ſuppoſed to derive its origin from a quantity of carbon, which, being diſcharged from the blood, combines with a portion of the oxygen air.

THE watery vapour which is expelled with the air that is expired from the lungs, is ſuppoſed to be formed in that organ by a combination of oxygen with a quantity of hydrogen, which is likewiſe diſcharged from the blood. But it is not unlikely that both the carbonic acid gas and the water, inſtead of being formed in the lungs, may come out of the blood, through the exhaling pores of that organ, ready formed; the blood having originally received it in that ſtate from the chyle, &c.

THE air then which is expired from the lungs, contains a ſmaller quantity of oxygen air than it did before, but it contains alſo ſome carbonic acid gas, and ſome water, in the form of vapour *.—Let us now examine the different parts of this theory.

IT is evident, from the foregoing facts and explanations, that the oxygen air is the only fluid capable of aſſiſting reſpiration and combuſtion, and that it is indiſpenſably neceſſary to animal life, ſince the common air is uſeful only on account of the oxygen it contains.

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* There are ſome modern philoſophers, who explain the phænomena of reſpiration without admitting the abſorption of oxygen by the blood. The blood, they ſay, in paſſing through the lungs, acquires a vermilion red colour, becauſe it depoſits a portion of its carbonated hydrogen upon the air; and it becomes again dark in the courſe of circulation, becauſe it combines with a freſh quantity of carbonated hydrogen. At the ſame time the oxygen of the common air which enters the lungs, by combining with the carbon and with the hydrogen, forms the carbonic acid gas with the former, and the watery vapour with the latter.—It may be eaſily perceived, that by only changing the name of carbon into that of phlogiſton, this explanation may, in a great meaſure, be made to coincide with Dr. Prieſtley's hypotheſis.

THE mixture of nearly one part of oxygen air and three parts of azotic gas, which forms the atmoſpherical fluid, is, in all probability, the beſt proportion of ingredients for the maintenance of life; ſince we find that with a ſmaller proportion of oxygen, not only the reſpiration becomes unpleaſant and laborious, but debility, convulſions, and other bad effects are produced; and on the other hand, that bad ſymptoms of another ſort are brought on by a greater proportion of it, ſuch as a preternatural heat, feveriſh pulſation, pains, inflammations, &c.

THE phænomena of reſpiration and of combuſtion are not only analogous, but they illuſtrate each other in an admirable manner. In atmoſpherical air a candle gives light ſufficient for ordinary purpoſes. In a leſs pure atmoſphere the light becomes too dim; and in pure, or nearly pure, oxygen air, the candle will indeed give a much brighter light; but it will waſte ſo very faſt, as not to laſt perhaps the twentieth part of the time it will in common air.

THAT the blood abſorbs the oxygen of the atmoſpherical air in the act of reſpiration, is a propoſition which a variety of experiments and analogies ſeem to prove beyond all doubt. When blood, recently taken out of the veins of an animal, is encloſed in a piece of bladder, and is thus expoſed to common air, or to oxygen air, it acquires a florid red colour, and part of the oxygen air is abſorbed. The ſame thing takes place within the body, *viz.* the air which is expired contains a ſmaller proportion of oxygen than it did before, and the blood which returns from the lungs to the heart, and thence proceeds through the arteries, is found to have acquired a bright redneſs in its paſſage through the lungs; it is therefore natural to conclude, that the blood has abſorbed the oxygen through the pores of the thin membrane, which ſeparates it from the air in the cells of the lungs *.

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* This membrane is certainly much thinner than common bladder. Dr. Hales conjectured the thickneſs of the former to be the thouſandth part of an inch.

THE probability of this concluſion is corroborated by ſtrong collateral proofs; as by obſerving that the arterial blood of animals that have been ſuffocated, or that have died for want of oxygen air, is far from being of its uſual florid red colour; as alſo by obſerving, that when a quantity of blood is confined in a veſſel full of air, the air is not ſo quickly contaminated or deprived of its oxygen by the preſence of arterial, as by that of venous blood. And it is even aſſerted, that a quantity of blood taken out of the carotid artery of a ſheep, being confined in a veſſel full of azotic gas, improved the gas ſo as to render it, in ſome meaſure, fit for reſpiration, ſo that ſome oxygen muſt have been imparted to it by the blood *. This experiment deſerves to be repeated with particular care.

THE decompoſition of air, and the abſorption of its oxygen in combuſtion and oxygenation of metallic bodies, are alſo analogous

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* Medical Extracts, vol. I. p. 70.

logous to the phænomena of reſpiration, and confirm the abſorption of oxygen by the blood in that proceſs.

IT is true that a ſmall quantity of carbonic acid gas is found in the air in which blood has been confined; but the formation of this gas does not entirely account for the diminution of the oxygen. Beſides, it is not improbable, as we ſaid above, that the carbonic acid gas comes out of the blood ready formed, at the ſame time that the blood abſorbs the oxygen.

BY examining the courſe and ſtate of the blood, we find that it preſerves its brilliant redneſs through all the channels which convey it from the lungs through the heart, and to the extremities of the body. But in the other veſſels, which receive it at the extremities of the former, and convey it through the heart as far as the lungs, the blood is of a dark purple colour. The former courſe is performed through the pulmonary veins, the left auricle and left ventricle of the heart, the aorta and its branches. The latter is performed through the branches and trunks of the aſcending and deſcending cava, the right auricle and right ventricle of the heart, and laſtly, through the pulmonary arteries, which convey it to the ſpungy cells of the lungs, where its colour is changed, &c.

THE blood, therefore, having acquired the oxygen in the lungs, conveys it as far as the extremities of the branches of the aorta, where the oxygen is depoſited, and the blood returns without it through the veins.

IT is difficult to ſay under what form is the oxygen combined with the blood, and what becomes of it at the extremities of the arteries where it is left by the blood. For want of direct experimental information concerning this intereſting point, we have only the light of analogy and conjecture to lead us in the inveſtigation of truth.

IN the combinations of the baſe of oxygen air with different bodies, ſuch as take place in combuſtions of every ſort and degree, three different effects muſt be particularly remarked. The firſt is, that the oxygenation is generally accompanied with colours of different intenſity; the red being produced more frequently than any other colour, as is the caſe with *mercurius calcinatus per ſe*, *red lead*, *crocus martis*, &c. The ſecond is, that by the acceſſion of oxygen a body is always rendered firmer or more compact. Thus, by the combuſtion of hydrogene and oxygen, water is produced, which is a much heavier and more compact ſubſtance than either of its two components; thus alſo by oxygenation oils are thickened, and metallic bodies are converted into a ſubſtance powdery indeed, but whoſe particles are firmer and harder than the ſame bodies in their metallic ſtate *. The third is, that a body loſes, in great meaſure, its capacity for containing caloric, and of courſe gives out heat whenever it paſſes from a rare into a more compact ſtate of exiſtence, and *vice verſa.* Thus water contains a great deal more of caloric than ice, but much leſs than ſteam; hence when ſteam is converted into water, it depoſits part of its caloric, *viz.* it communicates ſenſible heat to the ſurrounding bodies, &c.

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* It is in conſequence of the ſuperior hardneſs of its particles, that *crocus martis* (which is oxygenated iron) and

BY an eaſy application of thoſe facts to the phænomena of reſpiration, we are led to conclude, firſt, that the redneſs which the blood acquires in the lungs, indicates a real oxygenation of that fluid; ſecondly, that the oxygen is ſlightly attached to the blood, for the blood eaſily parts with it at the extremities of the arteries; thirdly, that the oxygen, which is depoſited by the blood at the extremities of the arteries, enters into combination with, and gives firmneſs

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and the oxyde of tin (commonly called *putty*) are employed for poliſhing the hardeſt ſteel, glaſs, and even agates.

neſs and ſolidity to, thoſe particles of matter which give increment and ſtability to the animal frame; fourthly, and laſtly, that as the bond of union between the blood and the oxygen is not very ſtrong, and as the union of the oxygen with other ſubſtances at the extremities of the body is much ſtronger, therefore it ſeems evident that the caloric of the oxygen air is not entirely evolved from it in the lungs; but that the greater portion of caloric is evolved at the extremities of the arteries, where the oxygen is more powerfully attracted by other ſubſtances than it is by the blood in the lungs. Hence it follows, that the origin of animal heat does not exiſt in the lungs only, but that it takes place, more or leſs, in every part of the body. And this ſhews why the whole body is nearly of the ſame temperature; whereas, if the caloric were evolved in the lungs only, that part of the body would be much warmer than any other, which is not the caſe *.

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* I am happy to find that this explanation coincides with the opinion of a very diſtinguiſhed and recent anatomical

WHAT diſpoſes the blood to abſorb the oxygen in the lungs, and what forces it to depoſit that principle at the extremities of the arteries, are queſtions which the preſent ſtate of knowledge does not enable us to anſwer ſatisfactorily. It has been ſuppoſed that the oxygen is attracted by the ferruginous particles of the blood, and that the redneſs of the blood is to be attributed to the red colour of the oxyde of iron. But ſince

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tomical writer, who expreſſes himſelf in the following words:

"But in reflecting upon this moſt difficult of all ſubjects, the generation of heat in the living body, many things are to be taken in the calculation, which ſeem, on the ſlighteſt glance, to be far more important than this depoſition of oxygene from the blood. It is a law of nature, to which, as far as we know, no exception is found, that a body, while it paſſes from an aerial to a fluid, or from a fluid to a ſolid form, gives out heat. Now, what is the whole buſineſs of the living ſyſtem but a continual aſſimilation of new parts, making them continually paſs from a fluid into a ſolid form? The whole nouriſhment of the body goes on in the extreme veſſels, and is a continual aſſumption of new parts. The extreme veſſels are continually employed in forming ſome acids, which appear naked in the ſecretions; in forming oxyds, ſince it has been proved by a variety of experiments, that the oxygen is attracted by, and combines with, a variety of other ſubſtances independant of iron or metals, I do not ſee the neceſſity of attributing the attraction of the oxygen to the ferruginous, more than to other, ingredients of the blood. Nor do I ſee the abſolute neceſſity of attributing the red colour to the particles of iron, ſince other ſubſtances, in which iron is not concerned, ſuch as the oxyde of mercury,

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oxyds, as the fat and the jellies of the membranous and white parts; in the various depoſitions of muſcle, bone, tendon, &c. for theſe are all continually abſorbed, thrown off by the urine, and inceſſantly renewed. They are continually employed in filling all the interſtices of the body with a bland fluid or halitus; they are continually employed in forming ſecretions of various kinds. In performing all this the power of the veſſels may do much; but the ultimate effect in each proceſs muſt be a chemical change, and perpetual changes will produce a conſtant heat. Place the organ and focus of this animal heat in the centre of the body, and you are embarraſſed in a thouſand difficulties; allow this heat to ariſe in each part according to its degree of action, and each part provides for itſelf." Bell's Anatomy, vol. II. p. 125.

cury, red lead, &c. owe their redneſs merely to the oxygen which they have imbibed.

IT is difficult to account for the formation of the carbonic acid gas, and of the watery vapour in the lungs; for if thoſe fluids be really formed in that organ by the combination of the carbone, and of the hydrogen, with the oxygene of the inſpired air; the whole, or nearly the whole, of the oxygen air would be ſo expended, and little or none of it would remain to be imbibed by the blood. The caloric likewiſe would be employed in the formation of thoſe fluids, inſtead of being diſperſed through the body. Is it not therefore more natural and more ſatisfactory to ſuppoſe, that both the carbonic acid gas, and the water, are ſeparated from the blood in the lungs, but not formed in that organ? It is certain that carbonic acid gas is introduced into the ſtomach by the aliments; and it is certain that the chyle conveys it to the blood, why then ſhould we ſuppoſe that there is another formation of this gas in the lungs? As for the watery vapour, we may account for it in the ſame manner; and indeed the exudation of water through the internal membranes of the human body, is ſo generally practiſed by nature for the purpoſe of keeping thoſe membranes, &c. ſoft and pliant, that it would be irregular not to admit the ſame exudation of water in the lungs alſo.

THE expulſion of putrid effluvia from the body is conſidered as another office of reſpiration. This is ſhewn by the offenſive ſmell of the breath of certain perſons, who have no bad teeth to account for it. But it is difficult to aſcertain in what caſes this may take place, and how far it may extend.

IT is with the appearance of probability ſuppoſed that the oxygen, which the blood depoſits on the various parts of the body, is partly expended in the exerciſe of muſcular motion; ſince we find, that after unuſual exertions of the body, a man breathes faſter, and likewiſe takes in much more air at a time, as if nature endeavoured by that means to recruit what has been lately expended in greater quantity than uſual.

THE azotic gas, which is the greateſt ingredient of common air, is conſidered as only a diluent of the oxygen air, and as being otherwiſe paſſive in the proceſs of reſpiration. Yet this diluent anſwers a variety of purpoſes; the principal of which is, that it expoſes a proper quantity of oxygen air to a great quantity of blood, which could not have been the caſe if the atmoſpherical fluid had conſiſted entirely of oxygen. This object is accompliſhed by the very extenſive ſurface which the lungs preſent to the air in its numerous cells; for the more numerous the cavities are, the greater is the ſurface; and, in fact, we find that in thoſe animals that are not much in want of air, and that muſt frequently ſuſpend their reſpiration for a conſiderable time, ſuch as the ſea-turtle and the frog, the lungs conſiſt of very few and very large cells.

THE great proportion of azotic gas in common air, does alſo adapt that fluid to the purpoſes of vegetation, and other natural proceſſes, the enumeration of which is incompatible with the limits of this Eſſay.

CHAPTER VI.

A general Idea of the Application of aerial Fluids for the Cure of Diſorders incident to the human Body.

CONSTANT obſervation has informed mankind, from time immemorial, that the air of certain places is more or leſs ſalubrious than that of other places; and that the various qualities of the air in different ſituations, are peculiarly favourable to certain conſtitutions. Phyſicians, availing themſelves of this natural variety, have long been in the habit of ſending their patients to ſuch places as experience and analogy indicated to be more favourable to their reſpiration. The ſharp air of one place was reckoned good for one diſorder, the damp air of a ſecond place was eſteemed uſeful in other caſes, the pure air of a third was recommended in particular diſeaſes, and ſo on. Howſoever defective and erroneous their knowledge of the real conſtitution of the atmoſphere may have been, howſoever they may have abuſed the application, yet certain it is, that the variety of effects, ſuitably to the different qualities of the atmoſpherical fluid in different ſituations, is atteſted by innumerable facts and univerſal obſervation. Previouſly to the late diſcoveries, the ideas of phyſicians reſpecting the different qualities and effects of the atmoſpherical fluid, were vague, and generally erroneous. Experience, which ſhewed them the advantages that had been obtained in a number of ſimilar caſes, was their beſt guide, and all beſides was doubt and obſcurity. The preſent ſtate of knowledge has, in great meaſure, diſſipated the clouds; ſince it has not only ſhewn the reaſons upon which certain qualities of the air depend, but has likewiſe furniſhed us with the means of procuring airs of oppoſite qualities, and of any degree of purity, at all times and places, as alſo of applying them in all the extenſive variety of quality, degree of purity, and length of time.

THE apparatus neceſſary for producing the various factitious airs, may be eaſily derived from the particulars that have been mentioned towards the beginning of this book; but for a general apparatus, that admits of compactneſs, cheapneſs, and a ſufficiently extenſive application, I cannot recommend any better than, or nearly ſo good as, that which was contrived by Mr. James Watt, engineer, of Birmingham; by means of which the artificial airs, of ſufficient purity, may be produced at a very moderate expenſe, and eaſier than by any other general method. Thoſe apparatuſes are now made for ſale, and a printed deſcription, with neceſſary practical directions for the uſe of its various parts, is given with each apparatus, which ſuperſedes the neceſſity of adding the ſame to the preſent work. I ſhall, nevertheleſs, reſerve, for the end of the book, a liſt of the principal precautions which ſhould be attended to in the management of Mr. Watt's, or of any other apparatus of this ſort, to which the practitioner may recur for extempore information.

THE artificial elaſtic fluids are applied to the lungs by the way of reſpiration, to the ſtomach and inteſtines, by means of injections, or in combination with fluids, and to the external parts of the body, merely by contact.

VARIOUS apparatuſes have been uſed for the reſpiration of factitious airs. The leaſt exceptionable air-holder for this purpoſe, conſiſts of a large glaſs receiver filled with the required ſort of elaſtic fluid, inverted, and ſwimming in water; out of which the air is reſpired by means of a bent glaſs tube, which, paſſing with its bent part through the water, projects one aperture above the water within the receiver, whilſt its other extremity is applied to the mouth of the experimenter.

INSTEAD of the above-mentioned bent tube, the receiver may have an aperture at its upper end, to which a tube is adapted, air tight, in an horizontal direction. But as this apparatus requires a large tub full of water for the receiver to ſwim in, which renders it rather cumberſome, and not very portable, therefore other contrivances have been ſubſtituted to the receivers. The machine more in uſe for this purpoſe, conſiſts of an oil-ſilk bag, furniſhed with a ſhort wooden tube or faucet, which, when the bag is full of the required aerial fluid, is applied to the mouth of the patient. Thoſe bags are filled with the proper aerial fluid by means of a glaſs receiver, which, beſides its large aperture, has a ſmall aperture with a ſtopple at the oppoſite end. The receiver being filled with the required air, and inverted in water, the ſtopple is removed from its ſmall aperture, and the wooden tube of the bag is applied quickly to it; then by preſſing the receivers down into the water of the tub, the air will be forced into the bag. But with the air-holders, which form part of Mr. Watt's apparatus, the operation is rather eaſier, for which, ſee the deſcription of the ſaid apparatus. The principal imperfection of theſe bags conſiſts in the ſmell of the oil-ſilk, which proves nauſeous, and almoſt intolerable to delicate perſons; yet this ſmell may, in ſome meaſure, be removed *.

INSTEAD

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* For this purpoſe Mr. Watt gives the following directions:—"To free oiled ſilk from its diſagreeable "ſmell, cut it into pieces of the ſize wanted for the "bags, and provide a ſmooth table ſomewhat larger "than the pieces of ſilk, and a flat board of the ſame "ſize as the table. Take charcoal freſh burnt in an "open fire, until it is free from ſmoke, extinguiſh it by "ſhutting it up in a clean cloſe veſſel, and reduce it to "powder. Sift this powder over the table to the "thickneſs of a quarter of an inch, or more, ſpread a

"piece

INSTEAD of oil-ſilk bags large bladders may be uſed; but as a bladder is not capable of holding a quantity of elaſtic fluid large enough for medicinal uſe, ſeveral of them ſhould be had in readineſs, each fur-

" piece of your ſilk upon it, and ſift upon that again another layer of your charcoal duſt, and thus proceed alternating the layers of ſilk, and charcoal, until the whole of your ſilk is depoſited; then lay your moveable board upon the top of all, and leave the whole undiſturbed for four or five days. If, upon removing the charcoal duſt, the ſilk has not loſt its ſmell entirely, repeat the proceſs. The charcoal duſt is to be ſwept off the ſilk, and the ſilk to be waſhed upon a table with a wet ſponge until it is clean. The bags muſt then be carefully ſowed up, and the ſeams anointed with japanner's gold ſize, taking care to uſe that kind which does not become brittle when dry. Green oiled ſilk ſhould be avoided, as it is ſtained by means of verdigris, which rots it; the yellowiſh ſilk is the beſt.

" It is neceſſary to obſerve here, that although oiled ſilk be the beſt ſubſtance known for making the bags of, it is very imperfectly air-tight; and although charcoal-duſt deprives it of ſmell for the time, yet as it can only attract the odoriferous particles from the ſurface, it re-acquires ſome ſmell by keeping, but by no means equal to what it had at firſt."

niſhed with a wooden or glaſs tube, like the oil-ſilk bags, through which they may be filled, &c.; ſo that when the air of one bladder is exhauſted, a ſecond bladder may be ſubſtituted, and ſo on. Several bladders might be eaſily made to communicate with each other, ſo that through one tube or faucet they might be filled all at once: four or five large bladders thus joined together, would contain about as much air as an ordinary oil-ſilk bag, which is a quantity, in moſt caſes, ſufficient for one application, and it would laſt about ſix minutes. The bladders have likewiſe an unpleaſant ſmell, which may alſo, in great meaſure, be removed *.

WHETHER the glaſs receiver, or the oil-ſilk bags, or the bladders be uſed, the patient muſt always take care to keep his noſtrils accurately ſtopped whilſt he draws

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* For this purpoſe turn the bladder inſide out, waſh it well with a weak ſolution of ſalt of tartar, then waſh it ſeveral times over with fair water, ſo as to remove every particle of alkali; laſtly, waſh it with ſpirit of wine.

the air into his lungs at every inſpiration, and to open them immediately after, ſo as to expel the air from his lungs through the noſtrils into the atmoſphere at every expiration, and not to return it into the bag or receiver. This operation is not eaſily performed by moſt perſons, and ſome there are who cannot perform it at all; in which caſe they breathe the ſame air backwards and forwards to and from the bag. But by this means the air of the bag, even when lime-water is contained in it, is contaminated ſo quickly as to do more harm than good.

THIS inconvenience, however, is completely obviated by the uſe of a little machine, which is to be interpoſed between the mouth of the patient and the faucet of the bag. It conſiſts of a ſmall box of wood, having three apertures, to the two oppoſite of which two ſhort tubes are faſtened; to the third, which is a lateral one, there is an external valve which will only permit the air's going out of the box into the atmoſphere. One of thoſe tubes is applied to the faucet of the bag, and it contains a valve which prevents the return of the air into the bag; the other tube is applied to the mouth of the patient, who has nothing more to do than to hold his noſtrils conſtantly ſtopped, and to breathe in a natural way as long as there is any air in the bag or receiver *; it being eaſy to underſtand that whenever he inſpires, the air will paſs from the bag into his lungs; but that at every expiration, the air will be forced through the lateral valve of the machine into the ambient air.

Of the various ſorts of elaſtic fluids, the carbonic acid gas is the only one that has been ſucceſsfully applied to the ſtomach or inteſtines, and for this purpoſe it may be adminiſtered two ways, *viz.* either in the aerial form in clyſters, or combined with different fluids and given through the mouth. For the former of thoſe purpoſes the gas muſt be firſt introduced into a bladder by the method already deſcribed. For the latter, the gas is either naturally contained in liquors, as in newly fermented liquors, yeaſt, certain ripe fruits, and mineral waters; or is to be firſt combined with the required liquors, in which caſe water is the fluid which is more generally uſed. This impregnation of water and other liquors with carbonic acid air, may be accompliſhed by various methods, ſuch as by pouring the liquor backwards and forwards from one veſſel to another, over the ſurface of vegetable ſubſtances that are in a ſtrong ſtate of fermentation; or by filling a veſſel partly with carbonic acid air, and partly with the required liquor, and then ſhaking it for a minute or two, &c. But the beſt way of performing this impregnation, is by means of a well-contrived machine, which has been long in uſe, and is generally known under the name of Dr. Nooth's glaſs apparatus, for making artificial mineral waters. There is, however, a contrivance for impregnating water with an incomparably greater quantity of carbonic acid gas, than that which can be accompliſhed in Dr. Nooth's apparatus. But this contrivance is kept a ſecret by the inventor, though the water, ſo highly impregnated by him, may be had in London at a moderate price.

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* There are ſeveral perſons who, with very little attention, can breathe through the mouth only; when this is the caſe, the keeping of the noſtrils ſtopped is ſuperfluous.

THE application of factitious airs to the external parts of the body, may be performed with the utmoſt facility. The aperture of a tube, which proceeds from the veſſel in which the gas is generated, may be directed towards the part which is affected; a bladder full of the required gas may be gradually preſſed, ſo as to throw a ſtream of the gas upon it; the part itſelf, as far as it is practicable, may be introduced into a veſſel full of the required air; or, laſtly, a ſmall glaſs funnel, with a bladder faſtened to its ſmall end, and filled with the required elaſtic fluid, may be applied over the part, with the edge of its large aperture cloſe to the ſkin, ſo as to prevent the eſcape of the gas into the circumambient air.

THE medical application of factitious airs, and the effects which have thereby been produced, are as yet labouring under all the viciſſitudes of truth and exaggeration, of accuracy and miſapplication, of ſhort experience and uncertainty. The anxiety of ſome perſons, the ignorance of others, the deſire of fame, the love of intereſt, and the fear of dangerous innovations, have alternately operated in favour and againſt the adminiſtration of the elaſtic fluids for the alleviation of diſorders incident to the human body. In the conflict of ſuch oppoſite powers, it is difficult to ſeparate truth from exaggeration and error; it is impoſſible to aſcertain the preciſe limits of their uſe and efficacy.

NOTWITHSTANDING thoſe weighty objections, I have endeavoured to collect, to examine, and to methodize all the uſeful information which I could procure relatively to the ſubject, in hopes that a comprehenſive view of it might promote the uſe, and in great meaſure prevent the abuſe, of a new claſs of remedies, which have all the appearance of proving very advantageous to mankind.

IN the uſe of oxygen air we have a ſingular ſtimulus, which admits of its being rendered more or leſs active by dilution with various proportions of common air. In its pure, or nearly pure, ſtate, it is a powerful exciter of ſuſpended animation; and when diluted with a conſiderable quantity of common air, it is a gentle ſtimulus, which, by invigorating the various parts of the animal body, by communicating firmneſs to the ſolids, and energy to the fluids, does frequently obliterate the cauſes of morbid habits.

THE uſe of azotic gas, and of the various ſpecies of hydrogen gas, produces a diminution of the irritability of the animal fibre to any degree, and hence it becomes uſeful in a variety of thoſe diſorders, which depend on an increaſed irritability, ſuch as inflammations, coughs, ſpaſms, &c.

IN the uſe of the carbonic acid gas we have a powerful antiſeptic, and in certain caſes a ſolvent of conſiderable efficacy.

THE uſe of pure oxygen air is confined to the purpoſe of exciting the dormant powers of ſuſpended animation, and it is, therefore, to be adminiſtered to children born apparently dead, or overlaid; to perſons ſuffocated by drowning, by ſteam of charcoal, by foul air, &c. whenever the circumſtances of the caſe may indicate a poſſibility of recovery.

THOSE caſes excepted, the reſpiration of pure, or nearly pure, oxygen air, is almoſt always attended with unfavourable ſymptoms, ſuch as a preternatural heat, eſpecially about the region of the lungs; a quickened and feveriſh pulſation; inflammation, &c. And thoſe ſymptoms come on after a ſhorter or longer uſe of the oxygen air, according to the particular conſtitution of the experimenter, and the purity of the gas.

BUT when the oxygen is diluted with much common air, *viz.* in the proportion of one to eight, and even as far as one to twenty, it then is a ſafe and very uſeful remedy, whoſe principal action conſiſts in giving tone, elaſticity, and conſiſtence to the fluid as well as to the ſolid parts of the body, and of courſe it promotes all the natural conſequences of thoſe effects, *viz.* it quickens languid circulation, it ſtrengthens the organs of digeſtion, promotes ſecretions, invigorates debilitated habits, and it aſſiſts nature in throwing off bad humours, and other lurking cauſes of diſeaſes.

IT has been obſerved, that ſome individuals can bear a much greater proportion of oxygen than others, which is analogous to the various diſpoſitions for all other applications. Thus a certain quantity of any remedy will act powerfully on ſome perſons, whilſt it will not be even felt by others. Thus alſo a certain quantity of food produces ſtrength and cheerfulneſs in ſome individuals, whilſt it produces ſickneſs and indigeſtion in others. It therefore becomes neceſſary, in the application of this remedy, to regulate the proportion of the two elaſtic fluids agreeably to the conſtitution of the patient, which may be eaſily accompliſhed by means of a very few trials.

IN the diluted ſtate, the oxygen air is adminiſtered by letting the patient breathe it for five or ten minutes once or twice a day. It might probably prove more efficacious, if it were breathed in a more diluted ſtate for a longer time; but the preceding mode has undoubtedly been attended with ſalutary effects.

HOWEVER ſlight this application may appear, however ſmall the unuſual quantity of oxygen which is thus introduced may be, the effects have been proved and confirmed by a variety of experiments and medical caſes. But independent of the experimental proof, the improbability of the effect will diſappear if it be conſidered, that the lungs of moſt perſons, and eſpecially of thoſe who labour under certain diſeaſes, are almoſt immediately relieved or affected by the tranſition from the air of one place to that of another; as by their going out of town, or even out of the houſe; and yet, as has been already obſerved, the difference between the air of a town and the air of the country, or of that of a houſe and of the external air, is ſo very trifling as hardly ever to be diſtinguiſhed by the eudiometer. Extremely minute, and almoſt inconceivably ſmall, quantities of matter can act with wonderful efficacy, when they are introduced into the circulation of the blood. The inoculation of the ſmall-pox, and the experiments with poiſons, furniſh ſufficient confirmation of this obſervation.

BY breathing a mixture of common and oxygen air, even when the latter does not exceed one-eighth part of the former, for about ten or fifteen minutes, the pulſe is generally quickened of a few ſtrokes, but it is almoſt always made ſtronger. The lungs, during the operation, are ſeldom ſenſibly affected; but on leaving off the mixed airs, and returning to the atmoſpherical air, a degree of tightneſs is frequently felt on the cheſt, which, however, gradually goes off and vaniſhes after a few minutes time.

WHEN debilitated habits breathe the diluted oxygen air for about a quarter of an hour once or twice a day, the improvement of their health is hardly ever conſpicuous in leſs time than a week or a fortnight; but after that period, they will find their ſtrength, their appetite, their digeſtion, their circulation, and other functions, ſenſibly improved; and this improvement goes on progreſſively to a greater or leſs degree, according as age, local indiſpoſitions, times of the year, and other circumſtances may allow.

THE mixtures of common air with azotic gas, or of common air and any ſpecies of hydrogen gas, are commonly denominated *reduced atmoſpheres*; for, in fact, they contain a ſmaller quantity of reſpirable fluid, than is contained in an equal quantity of common air. The principal effect of thoſe reduced atmoſpheres, is to diminiſh the irritability of the parts ſubſervient to reſpiration, and indeed of the whole body; for which reaſon they are ſucceſsfully adminiſtered in inflammations of the lungs, in ſpaſmodic coughs, and in all the diſorders that are nearly allied to thoſe.

MUCH caution muſt be uſed in the adminiſtration of thoſe reduced atmoſpheres, as ſome of them are productive of alarming ſymptoms. The mixture of azotic and common air, in which the former ſhould never be more than a quarter of the latter, is the leaſt dangerous, and at the ſame time the leaſt efficacious. The ſame thing may be ſaid of the mixture of common air with the mild ſort of hydrogen gas, *viz.* that which is produced from iron and diluted vitriolic acid, or by paſſing the ſteam of water over red hot iron, excepting that it is rather more efficacious than the preceding. But the hydrocarbonate is much more powerful and more dangerous than any of the abovementioned gaſſes, eſpecially when freſh made. It ſhould, in general, be mixed with about twenty or thirty times its bulk of common air, unleſs ſome particular caſe may ſeem to require a greater proportion of the dangerous gas. For moſt purpoſes it will ſuffice to breathe it for about five minutes a day.

THE breathing of the diluted hydrocarbonate is attended with a diminution of ſenſibility, eſpecially about the cheſt, and this effect is frequently ſo great, that ſome perſons have expreſſed it by ſaying, that they felt as if they had no lungs at all, even when they had been a few minutes before in excruciating pains. But this diminution of ſenſibility is almoſt always accompanied with vertigo or giddineſs, with a lowering of the pulſe, and with faintneſs. It muſt be particularly remarked, that though thoſe ſymptoms in general come on immediately after the operation, yet ſometimes they return once, and even twice, more in the courſe of the day. When the breathing of reduced atmoſpheres proves very troubleſome, it may be interrupted for a few minutes.

ITS great power in checking irritability and ſenſibility, ſeems to render the diluted hydrocarbonate applicable to ſome diſorders that have hitherto eluded all medical application; and as one of the moſt likely to be relieved by this treatment, I ſhall mention the hydrophobia, or madneſs which is occaſioned by the bite of mad dogs, or other mad animals *.

A REDUCED atmoſphere, capable of diminiſhing in ſome degree the irritation of the lungs in inflammations, coughs, and

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* I have been told, and have read, though I cannot at preſent recollect where, that the uſe of opium, and likewiſe that the ſuſpenſion of animation for a time by accidental drowning, have actually cured the hydrophobia in two or three caſes. If this be true, the probability of the hydrocarbonate proving beneficial, is thereby much increaſed.

certain ſpecies of aſthma, has been expeditiouſly formed by mixing the vapour of vitriolic ether with common air. For this purpoſe the patient needs only hold a ſmall phial of ether open near his mouth, for about an hour at a time or longer, by which means the vapour of the ether mixes with the air that enters the lungs in the uſual courſe of reſpiration, and converts it into an inflammable, or rather an exploſive, aerial fluid *. For this purpoſe it has been found uſeful to mix ſome powdered leaves of hemloc *(cicuta)* with the ether. The ether *(viz.* about a quarter of an ounce of it) may alſo be put in a common tea-pot, and the mouth may be applied to the ſpout of it, ſo as to draw the air through it, and through the vapour of the ether.

THE carbonic acid gas has been longer in uſe as a medicine than any other factitious

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* If three or four drops of ether be ſhook in a phial full of common air, and if afterwards the aperture of the phial be preſented to the flame of a candle, the air in it will explode like a mixture of common air and hydrogen gas.

tious aerial fluid. Much has been done, and much has been written, relatively to it. But the uſeful reſult of thoſe experiments and inveſtigations will be found condenſed in the following few paragraphs.

IN putrid fevers the free uſe of carbonic acid gas has been of conſiderable uſe, whenever the urgency of the caſe has not been very great, *viz.* when time was allowed for the gas to operate upon the morbid matter; and when the diſtention of the bowels was not ſo great as to prevent the free uſe of the gas.

IN the ſcurvy this gas has been of conſiderable uſe in the beginning of the diſorder, rather more than in an advanced ſtate of it. But the uſe of vegetables, of ſugar, and of other ſubſtances that contain it in great abundance, are acknowledged to be uſeful in all ſtates of that diſorder. Experience likewiſe inform us, that in the uſe of carbonic acid gas we are not to expect an unlimited antiſeptic, nor a perfect ſolvent of the ſtone in the urinary bladder; yet its uſe in putrid caſes, and in ſome diſeaſes of the bladder or kidnies, is attended with conſiderable benefit.

THE external application of carbonic acid gas to ſores and ulcers of every ſort, is unqueſtionably very uſeful.

AFTER a careful conſideration of the preceding general and comprehenſive proſpect of the medicinal uſe and efficacy of the aerial fluids, we may eaſily regulate the meaſure of our hopes by the ſtandard of reaſon and experience. The idea of finding in them a remedy, capable of curing conſumptions in all their ſtages, muſt be laid aſide; and the hope of healing all ſorts of internal ulcers will naturally vaniſh. The uſe of reduced atmoſpheres does undoubtedly diminiſh the irritability of the fibre, and a diminution of irritability favours the healing of certain ulcers, but by no means of them all; nay, in ſome caſes it will even produce the contrary effect. The uſe of oxygen air has been ſound advantageous in many of thoſe diſorders that are called nervous, and it has undoubtedly ſtrengthened and invigorated ſeveral debilitated or emaciated habits; but it would be abſurd to expect that it ſhould prove beneficial in all caſes of emaciation and debility, ſince thoſe viſible effects are often produced by cauſes that may be rather fomented than checked by the uſe of oxygen air.

IN moſt of the diſorders incident to the human body, the various concurring circumſtances are far from being known to their full extent; hence theory may ſuggeſt, but experience muſt prove the uſe of certain practices. Improvements and diſcoveries may be generally urged and expected; but where theory and experience are ſilent, we have no warrantable guide to aſſiſt us in the inveſtigation of new properties and new applications.

CHAPTER VII.

Of the particular Adminiſtration of aerial Fluids in different Diſorders.

AFTER a general idea of the application of factitious airs by way of remedies to the human body, it will be neceſſary to ſtate thoſe modes of treatment, which experience or analogy ſhew to be the moſt efficacious in particular diſeaſes. But this ſtatement cannot be attended either with great accuracy of deſcription, or with extenſive information concerning the phænomena, that are really produced by the factitious airs in all caſes. The various nature of individuals, the imperfect accounts of ſeveral caſes, and the frequent adminiſtration of other medicines in conjunction with the aerial fluids, limit for the preſent the attainment of the abovementioned objects.

ALL that the practitioner may expect to derive from the preſent chapter is, a guide or indication for the commencement of the application, a general view of the principal effects that are produced by the particular adminiſtrations, and a warning againſt miſtakes. But with reſpect to the continuation, or ſuſpenſion, or alteration, of the treatment, he can only be inſtructed by a careful obſervation of the phænomena which take place in the courſe of the application.

I SHALL forbear mentioning other medicines that may be proper to be adminiſtered at the ſame time with the gaſſes, as theſe muſt be left to the judgment of profeſſional gentlemen. But I would ſtrongly recommend to adminiſter them as ſparingly as the nature of the caſe can poſſibly admit of; being perſuaded, that the good effects of the aerial fluids is frequently counteracted by the action of other medicines.

N. B. The diſeaſes in the following pages are arranged in alphabetical order.

Animation ſuſpended.

IN caſes of this ſort, whether they be occaſioned by drowning, by noxious vapours, or by any other cauſe of the like nature, the oxygen air ſhould be adminiſtered pure, or nearly ſo. The wooden pipe of a large bladder full of it muſt be introduced into the mouth of the ſubject, the lips muſt be preſſed upon the ſaid pipe, and the noſtrils muſt be ſtopped by the hands of an aſſiſtant. Then by preſſing the bladder, the oxygen air muſt be forced into the lungs, as much as poſſible, for about eight or ten ſeconds, after which the mouth and noſtrils being unſtopped, without removing the pipe of the bladder, the cheſt about the region of the lungs muſt be preſſed gently; then the bladder being applied as before, the oxygen air is forced again into the lungs, and ſo on; continuing a ſort of forced and artificial reſpiration for about a quarter of an hour at leaſt, if no ſigns of life appear before that time *. But as ſoon as any natural or ſpontaneous movements are perceived, the preſſing of the region of the lungs may be diſcontinued, and the bladder, &c. muſt be removed; for in that ſtate a free ventilation of the ambient air will be found ſufficient to reſtore life.

THIS treatment ſhould be accompanied with the communication of a gentle warmth, and perhaps with friction to the hands and feet. But care muſt be taken to do what is juſt neceſſary, and not too much; for in the attempts to reſtore animation, the ſtimuli and other applications are frequently carried ſo far, as to deſtroy that laſt ſpark of life, which they were intended to revive.

IN caſes of children born apparently dead, or ſtrangled in laborious parturition, &c. the uſe of oxygen air cannot be too forcibly recommended. The application is eaſy and highly promiſing. Independent of

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* Several bladders full of oxygen air ſhould be kept in readineſs, for a ſingle bladder will be ſoon exhauſted.

the experiments that have been made on brutes, I know of a caſe, in which a child born apparently dead, was brought to life merely by forcing oxygen air into his lungs, whilſt he was held before the fire.

Aſthma.

I FIND many creditable accounts of this diſorder having been relieved, and ſometimes perfectly cured, by the uſe of diluted oxygen air in ſome caſes, and by the uſe of reduced atmoſpheres and the vapour of ether in other caſes.

IT would be abſurd to imagine, that either of thoſe treatments may be indiſcriminately applied to the very ſame ſpecies of aſthma; but the diſtinctions are not clearly ſtated in all the accounts of the caſes. It appears, however, that in a plethoric aſthma, and when the diſorder is attended with conſiderable pain, hard cough, and inflammatory ſymptoms, the reduced atmoſpheres muſt be adminiſtered.

IN thoſe caſes the patient may be directed to breathe daily ſixteen quarts of common air, with four quarts of hydrogen, obtained from iron and diluted vitriolic acid, or, which is better, from the vapour of water and red-hot iron. But ſhould this mixture of elaſtic fluids prove ineffectual in a day or two, then a mixture of one pint of hydrocarbonate and thirty pints of common air, may be uſed inſtead of it; and the ſtrength of this mixture may be increaſed according to circumſtances. If in breathing the diluted hydrocarbonate, giddineſs ſhould come on, the patient muſt be deſired to intermit the operation; reſting, that is breathing the ambient air, for a few minutes, and then to reſume the inhalation of the diluted hydrocarbonate. Thus the operation may be intermitted three or four times.

THE breathing of the vapour of ether, after the manner deſcribed in the preceding chapter, has been found to afford conſiderable alleviation of the pain and oppreſſion in thoſe caſes.

IN nervous aſthma, and eſpecially in debilitated habits, the oxygen air may be adminiſtered; and it will be proper to begin by inhaling daily eight quarts of common, with two quarts of oxygen, air, extracted from manganeſe by means of heat. The quantity of oxygen may be increaſed, in caſe the abovementioned proportion ſhould be found ineffectual; and it is remarkable, that in this ſpecies of diſeaſe the patients can ſometimes bear a great quantity of oxygen without any material effect.

IN all caſes of aſthma, the effects of the application of factitious airs may be perceived in the courſe of four or five days; but the accompliſhment of the cure will frequently require ſix weeks time, or longer.

Cancer.

THE ſtubborn nature of a cancer, and its dreadful conſequences, render every hint, that promiſes an alleviation of its effects, extremely intereſting.

THE elaſtic fluids have been repeatedly applied to caſes of this ſort, and ſuch applications have been attended with conſiderable advantage. I do not find any authentic account of a cancer having been completely cured by the uſe of factitious airs. But certain it is, that in a variety of caſes the pain has been conſiderably diminiſhed, the fœtor as well as the bad aſpect of the ulcer, have been almoſt entirely removed, and the whole habit of body has been conſiderably improved, ſo that the patients have thereby been enabled to have comfortable nights, more cheerful countenances, &c.

THOSE good effects have been produced by the external application of carbonic acid gas to the ulcer, and the inhalation of diluted oxygen air. Both thoſe elaſtic fluids muſt be adminiſtered daily for weeks, or as long as the indications of the caſe may afford a hope of melioration. The manner of applying the carbonic acid gas has been already deſcribed [*]; as for the continuance of the application, an hour a day is by no means too much, and it would be better if ſuch an application were repeated two or three times in the courſe of each day. With reſpect to the oxygen, two or at moſt three quarts of it, with about fourteen or ſixteen quarts of common air, may be ſufficient for each daily inhalation.

Catarrh.

IN colds and defluxions, eſpecially when accompanied with tightneſs about the region of the lungs, and a hard cough, much and almoſt inſtantaneous relief has been frequently obtained by breathing a mixture of about four quarts of hydrogen and twenty quarts of common air. There is no need of breathing this quantity at once. It will hardly ever be neceſſary to repeat this application longer than the third day. The breathing of the vapour of ether in the manner already deſcribed, will anſwer nearly as well as the above-mentioned mixture of elaſtic fluids, and it has the advantage of being a much eaſier application, ſince it requires no particular apparatus *.

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[*] See chap. VI. p. 99.

Chloroſis.

THE adminiſtration of diluted oxygen air has proved beneficial in diſeaſes of this kind, perhaps more often than in any other diſorder, as is proved beyond a doubt by ſeveral authentic caſes. The paleneſs, the debility, the palpitation, the fever, the depraved appetite, and the other bad ſymptoms which accompany this diſorder, generally begin to diminiſh in about four or five days, and a complete cure is often accompliſhed in about ſix weeks time.

THE daily inhalation of one quart of oxygen, and ten or twelve quarts of common, air, may ſuffice for the beginning. But it

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* See chap. VI. p. 110.

is to be remarked, that chlorotic patients are ſenſible of the leaſt exceſs in the proportion of oxygen, ſo that ſometimes they are more hurt than benefited by it, unleſs ſuch a quantity of it be adminiſtered as may be juſt neceſſary; and this quantity can be ſhewn only by a careful obſervation of the effects which take place. The lungs will be enabled to bear the ſtimulus of oxygen air every day better and better.

Conſumption.

THE various ſtates of conſumption, or *phthiſis pulmonaris*, its different cauſes, and the difficulty of diſcerning a real phthiſis from certain other diſorders, render the treatment of this diſeaſe frequently doubtful and perplexing. But its ſtubborn nature, and the frequency of the diſeaſe, demand the utmoſt attention, and all the aſſiſtance which philoſophy can ſuggeſt, and the medical art can apply. We ſhall therefore endeavour to ſtate, how far the uſe of factitious airs has been found uſeful or promiſing in caſes of this nature.

IT has been ſaid on one ſide, that the factitious airs have the power of arreſting the progreſs of conſumption, and often of accompliſhing a perfect cure; but on the other hand it has been aſſerted, that they have never afforded any permanent benefit, and that they have often produced manifeſt harm. It appears, however, from a diſintereſted examination of the caſes, and from the teſtimony of patients as well as of practitioners, that both thoſe aſſertions imply a conſiderable degree of exaggeration. The reſult of this examination will be found condenſed in the following paragraphs.

THE diluted hydrocarbonate is the only one, or at leaſt the principal aerial fluid that has been ſucceſsfully adminiſtered in caſes of phthiſis; and it has generally afforded a ſenſible and almoſt immediate relief, by abating the hectic fever, by diminiſhing ſenſibility, by promoting ſleep, and by reducing the quantity of expectoration.

BUT the uſe of hydrocarbonate is always attended with a diminution of ſtrength.

Hence, when the patients are very feeble, which is generally the caſe in an advanced ſtate of the diſorder, the diſadvantage which ariſes from the diminution of ſtrength, is greater than the advantage which ariſes from the other good effects of the hydrocarbonate. When the patients, therefore, are too far gone, the uſe of the hydrocarbonate produces an apparent but not a real melioration.

IT is on the ſame account that this elaſtic fluid cannot be adminiſtered to patients, that labour under great weakneſs of the digeſtive organs. In ſuch caſes the vapour of ether is, perhaps, the only elaſtic fluid that may be tried with ſafety; and the uſe of it is attended with at leaſt a temporary relief.

THERE are two or three caſes of real phthiſis creditably related, where a perfect cure ſeems to have been performed; though in a great many others the application of aerial fluids proved evidently uſeleſs. But though from thoſe few ſucceſsful caſes no great expectations can be derived, yet in a diſeaſe where no remedy has ever been found efficacious, ſurely it is not improper to try an application which at leaſt affords a ray of hope.

THE quantity of diluted hydrocarbonate, which may be adminiſtered daily, is various, according to the conſtitution of the patient. It is proper, however, to begin by adminiſtering one pint of hydrocarbonate with between twenty and thirty pints of common air; and the quantity of the former may, in proceſs of time, be increaſed conformably to the effects. In breathing this quantity of elaſtic fluid, it will be proper to let the patient reſt four or five times, or in ſhort whenever any giddineſs happens to come on; for this giddineſs or vertigo generally goes off in two or three minutes, after which the patient may again apply his mouth to the bag or veſſel which contains the diluted hydrocarbonate.

IT will be found, that cuſtom habituates the lungs to bear the hydrocarbonate, in an increaſed proportion, as far as a certain limit. Thus the ſame patient who at firſt was made vertiginous by a quart of hydrocarbonate, diluted with twenty quarts of common air, will, in proceſs of time, be hardly affected by the double of that quantity.

THE inhalation of the vapour of ether, as alſo of other ſorts of reduced atmoſpheres, ſuch as a mixture of azote and common air, of carbonic acid gas and common air, of hydrogen and common air, have been of partial uſe; however, the mixture laſt-mentioned ſeems to have proved more beneficial than any of the reſt. This ſort of reduced atmoſphere muſt be adminiſtered more freely than the diluted hydrocarbonate. The vapour of ether may be inhaled with the utmoſt facility, as no apparatus is required for it, and it will be found at leaſt of temporary uſe for allaying the cough, the pain, &c.

THOUGH the uſe of reduced atmoſpheres be more promiſing in caſes of incipient phthiſis, yet that application ſhould not be neglected in any ſtate of the diſorder; ſince the elaſtic fluids are the only remedies which can be applied immediately to the part affected.

OF the various ſpecies of phthiſis pulmonaris, two only, *viz.* the chlorotic and the ſyphilitic, ſeem to require a different treatment, and I find a few caſes in which ſyphilitic ulcers in the lungs are ſaid to have been cured by the uſe of diluted oxygen, which was breathed once a day; but this treatment was accompanied with mercurial and other medicines; which, however, when adminiſtered by themſelves, had produced no good effect.

THE inhalation of carbonic acid gas is ſaid to have proved beneficial in hectic diſorders, but I do not know how far this practice may be ſafe or uſeful, as I do not find any very particular information concerning it.

Coughs.

OF the various ſpecies of cough, thoſe which originate from catarrh and from phthiſis have been already mentioned under thoſe articles, to which the reader is referred. But with reſpect to the application of factitious airs to other ſpecies of cough, I do not find much authentic information, and of courſe muſt leave it for future inveſtigation.

Debility.

AN univerſal debility is not unfrequently met with amongſt perſons of all ages, and eſpecially among women. It is ſometimes the unconquerable effect of former diſorders that are ſubdued, or of lurking and inviſible cauſes. Whatever its origin may be, the ſymptoms it produces are numerous and often of the utmoſt conſequence. It produces paleneſs, emaciation, difficulty of breathing, palpitation, indigeſtion, loſs of ſleep, frequent cough, ſwellings of the extremities,

tremities, weakneſs of ſight, loſs of voice, ſuppreſſion of the uſual evacuations, &c. Thoſe ſymptoms, of which a greater or leſs number is to be obſerved in the ſame individual, are, at firſt, the conſequence of the debility, but they ſoon become the fomenters of that very languor, and conſequently of each other.

WHEN the diſeaſe, which produces the languor, is preſent and known, I need hardly mention that the removal of that cauſe ſhould be the firſt object of the practitioner. But when that is not the caſe, diluted oxygen air may be adminiſtered with great hopes of ſucceſs; for ſuch treatment has been found beneficial in a great many caſes of this ſort, and wonderful cures have been performed where no other remedy was found efficacious. The improvement is perceived ſooner or later, according to the nature of the caſes; but, generally ſpeaking, it becomes manifeſt in about a fortnight or three weeks time. It operates by ſtrengthening and improving the whole habit. The pulſe becomes ſtronger, the aſpect acquires colour, the laſſitude after exerciſe goes off gradually, the appetite is improved, and the reſt of the ſymptoms diſappear gradually.

IT has been repeatedly obſerved, that in caſes of this ſort the quantity of oxygen muſt be nicely regulated by the ſtrength of the patient. If too ſmall a quantity be adminiſtered, little or no improvement will be obtained; but if the quantity be too great, the effects will be hurtful, and ſome of the bad ſymptoms are thereby increaſed. A few days experience will ſoon indicate the proper doſe of oxygen. But I would recommend to begin by giving one quart of oxygen, with twelve or fifteen quarts of common, air, per day, and to increaſe or diminiſh the quantity according to circumſtances. It muſt, however, be remembered, that when a ſenſible improvement becomes manifeſt, more advantage is to be derived from a moderate doſe regularly adminiſtered, than from an increaſed proportion of oxygen.

I DO not find that the leaving off of this application has ever been productive of any harm, but at all events it may be not improper to relinquiſh it by degrees, *viz.* by diminiſhing the quantity of oxygen, and intermitting the application by the interval of a day or two.

Digeſtion impaired, or Dyſpepſia.

WE have not a clear account of the various ſpecies of dyſpepſia to which the aerial fluids have been applied, nor indeed have they been tried in a great variety of caſes. But upon the whole it appears, that when debility is the cauſe, and eſpecially when it is accompanied with what is called a nervous head-ach, the inhalation of diluted oxygen air has been of ſingular uſe, and the diſorder has been frequently removed in a ſhort time.

IF the impaired digeſtion be accompanied with other ſymptoms of debility beſides the head-ach, the adminiſtration of oxygen may be regulated agreeably to what has been mentioned in the preceding article, otherwiſe a greater proportion of it may be adminiſtered, as about four or five, or ſix pints of it, with between twenty and thirty of common air. In caſes of this ſort, the good effects of the oxygen may be perceived in the courſe of a few days.

THIS treatment has proved peculiarly beneficial to ſuch perſons as have contracted a weakneſs of digeſtion, from having been confined in the foul air of workſhops, counting-houſes, &c.

I FIND, likewiſe, the caſe of a man who had been afflicted for upwards of five years with heart-burn, flatulence, lowneſs of ſpirits, and coldneſs of the extremities, which ſeemed to indicate a bad digeſtion, and who was perfectly cured by the inhalation of diluted oxygen, and by drinking water impregnated with carbonic acid gas, together with ſome ſalt of ſteel.

Dropſy.

IN a variety of dropſical caſes the inhalation of diluted oxygen air has been attended with ſucceſs, and this ſucceſs has ſeveral times amounted to a complete cure. This treatment ſeems to be more efficacious in an incipient dropſy, and when the diſorder is confined to the extremities, than in other ſtates of it. Yet I find a remarkable caſe of hydrothorax which was effectually cured, though a ſimilar one was not attended with the ſame effect; and likewiſe a caſe of water in the head of a boy of thirteen years, which is ſaid to have been partially removed by the inhalation of diluted oxygen air.

ONE quart of oxygen, and about fifteen of common air, per day, may be ſufficient for the beginning; but the proportion of oxygen muſt be increaſed in the courſe of three or four days (provided no bad effects enſue) to two quarts; and ſoon after it will be proper to double the quantity both of oxygen and of common air.

THIS regimen muſt be perſiſted in for weeks and months, according to the nature of the caſe; and ſhould any inflammatory ſymptoms appear in the courſe of this application, the inhalation of the diluted oxygen may, in that caſe, be ſuſpended or moderated for two or three days.

Eruptions.

I FIND a few caſes of ſcorbutic eruptions on the face, as alſo on other parts of the body, in which a complete cure was accompliſhed by the daily inhalation of diluted oxygen air.

IN caſes of tumors and eruptions, which derive their origin from debility and a poor or thin ſtate of the blood, the like treatment has been found beneficial.

Two or three pints of oxygen, with about ten times that quantity of common air, per day, is ſufficient for the beginning; but in caſes of this ſort, the proportion of oxygen ſhould not be much increaſed.

I NEED hardly add, that in ſuch caſes it is proper to continue the uſual dreſſings of the parts affected, the means of keeping the body gently open, &c.

Fevers.

I DO not know whether the factitious airs have been tried with ſucceſs in other ſorts of fever, beſides the putrid and the hectic. With reſpect to the latter, the reader may conſult what has already been ſaid under the articles of *chloroſis* and *conſumption*. But in putrid fevers the carbonic acid gas is generally allowed to be an uſeful remedy; yet the uſe of it has not proved ſo generally beneficial as it was at firſt believed.

THIS gas is applied internally, not to the lungs but to the ſtomach and inteſtines, in three different manners, *viz.* by way of clyſters, either in the aerial form or in combination with water; by way of drink when combined with water; and, laſtly, by giving through the mouth ſuch ſubſtances as contain carbonic acid gas in abundance, that is liquors in a ſtate of fermentation, certain fruits, &c.

WHEN a large quantity of it is given either in the aerial form or in combination with water, the abdomen is frequently diſtended by it; for though this gas is pretty eaſily imbibed by animal fluids, the fluids which it uſually meets with in the ſtomach, &c. are ſeldom capable of abſorbing more than a moderate quantity of it. However, the diſtention of the abdomen is not ſo very detrimental, but it may be ſupported to a certain degree.

WHAT ſeems to render the carbonic acid gas not ſo efficacious in caſes of putrid fevers, as from its uſual properties one might be led to expect, is the difficulty of its inſinuation into the vaſcular ſyſtem of the whole body. The lacteals imbibe it in ſmall quantity, and the difficulty becomes greater in certain ſtates of the diſorder; whenever, therefore, the diſeaſe is not in a very alarming ſtate, *viz.* ſo as to give time for the inſinuation of the carbonic acid gas into the fluids of the body, then more benefit is to be expected from it. There are, however, ſome caſes in record, where the free uſe of carbonic acid gas proved efficacious in the worſt ſtate of putrid diſeaſes; and I do not find that it was ever attended with noxious effects.

OF the various ſubſtances which are adminiſtered in putrid diſeaſes, on account of the carbonic acid gas which they contain, the following are the principal ones, *viz.* effervеſcing alkaline and acid mixtures, conſiſting of a ſolution of ſalt of tartar, to which lemon juice, or diluted vitriolic acid, or diluted nitrous acid, is added the moment before it is to be drank; ſweetwort, or an infuſion of malt, yeaſt, and certain acidulous fruits, ſuch as oranges, lemons, &c.

I SHALL not attempt to define the circumſtances in which one or other of thoſe articles may be preferable, nor is it neceſſary to limit the doſes. The circumſtances of ſuch caſes being very numerous and diverſified, muſt be left to the ſkill of the attending practitioners. If the carbonic acid gas be adminiſtered in the aerial form, the quantity of it can hardly be too great, provided it does not diſtend the abdomen too much; but if the gas be given in combination with other ſubſtances, the quantity of thoſe other ſubſtances muſt be limited, not by the quantity of carbonic acid gas that may be contained in them, but by their other properties, which muſt be proportionate to the ſtate of the patient.

IT has been propoſed (not without expectations of ſucceſs, though with difficulty of execution) to introduce, in certain caſes, the whole body of the patient, the mouth excepted, into a veſſel full of carbonic acid gas; for as this gas is abſorbed by the pores of the ſkin, a greater quantity of it might thereby be imbibed.

Head-Ach.

THE various origin of this diſorder, and the ſmall number of caſes that are circumſtantially related, prevent our forming a comprehenſive idea of the uſe of factitious airs in caſes of this ſort. The inhalation of diluted oxygen air, has ſometimes been of uſe in what is commonly called nervous head-ach; and it appears that in ſuch caſes, a very great proportion of oxygen air has been adminiſtered, even as much as five or ſix gallons per day. I would not, however, recommend ſo free a uſe of it.

In head-achs that ariſe from a weak digeſtion, the inhalation of diluted oxygen air is an uſeful remedy. See the article *Digeſtion.*

Hæmoptyſis, or Spitting of Blood.

I FIND a few caſes of this diſorder, in which the adminiſtration of hydrocarbonate gas was adminiſtered with good effect. The account of the moſt remarkable one will be found in the next chapter.

Ophthalmia.

IN caſes of ophthalmia, and weakneſs of ſight, when accompanied with a relaxed habit of body, the inhalation of diluted oxygen air has been of ſingular uſe. About two quarts (when a ſmaller quantity has proved ineffectual) of oxygen air, with about fifteen of common air, is a doſe ſufficient for each day.

Phthiſis Pulmonalis.

See *Conſumption.*

Paralyſis.

I FIND a few caſes of that ſpecies of paralyſis which is occaſioned by preparations of lead, the *colica pictonum*, where the inhalation of diluted oxygen air proved beneficial. Three or four pints of it, with about thirty pints of common air, is a doſe ſufficient for each day.

Scurvy.

THE uſe of carbonic acid gas has long been conſidered as a powerful remedy in ſcorbutic diſorders; and certain it is, that when the diſorder is not too far advanced, a perfect cure may be generally expected from it; and even in caſes of the worſt ſort, the free uſe of this gas has frequently accompliſhed a perfect recovery.

ALL the various ways of adminiſtering this gas, which have been mentioned for the cure of putrid fevers (See the article *Fevers*)

Fevers) are applicable to this ſort of diſorder.

SINCE much has been written concerning the ſcurvy, and ſince the methods of adminiſtering ſuch ſubſtances as contain abundance of carbonic acid gas, are generally known and ſucceſsfully adminiſtered, I ſhall not detain the reader with long extracts from more able writers; but ſhall only add, that, whilſt the carbonic acid gas is applied to the ſtomach and inteſtines, a moderate doſe of diluted oxygen air ſhould be applied to the lungs by the way of reſpiration; for whilſt the former acts as an antiſeptic, and corrects the putrid tendency, the latter gives energy and vigor to the fibre, and enables the body to throw off the morbid humours with greater quickneſs.

Stone in the Bladder, &c.

WATER impregnated with carbonic acid gas, has been long known to afford relief in calculous complaints of the bladder and urinary paſſage. But by the addition of a fixed alkali, the remedy has of late been rendered much more efficacious in caſes of the above-mentioned ſort, and even when a large ſtone has actually exiſted in the bladder. I do not know how far this *acidulous ſoda water*, as it is commonly called, may operate by way of a ſolvent of a large ſtone; but certain it is, that even in thoſe caſes it affords conſiderable relief, and it ſeems effectually to prevent the farther accumulation of the ſtony matter, by diſſolving the mucus as well as the ſmall ſtony concretions, and waſhing them off from the kidnies, ureters, bladder, &c. It is, therefore, given in all complaints that originate from a thickening of, or depoſition of groſs matter by, the urine in the above-mentioned parts, ſuch as ſtrangury, pain in voiding the urine, ulceration of the parts, &c.

For this purpoſe one ounce of ſoda is diſſolved in four or five pints of rain, or of boiled ſoft, water; and the ſolution is then impregnated, as much as poſſible, with carbonic acid gas *. Of this water, a pint a day is the quantity uſually given for the above-mentioned diſorders, and it is to be drank not all at once, but at three different times, *viz.* morning, noon, and night.

INDEPENDENT of thoſe diſeaſes, the acidulous ſoda water is ſucceſsfully adminiſtered in ſcorbutic caſes, bilious complaints, weakneſs of the digeſtive organs, ſome nervous affections, &c. but in thoſe the proportion of the alkali, as well as the daily allowance, muſt be diminiſhed according to the circumſtances of the caſe.

Swellings.

I FIND one caſe only of a white ſwelling of the knee recorded, in which a per-ſect cure is ſaid to have been accompliſhed by the daily inhalation of diluted oxygen air. As thoſe ſwellings owe their origin in great meaſure to weakneſs of body, it is likely that the uſe of oxygen, which invigorates the animal fibre, may prove an uſeful remedy.

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* In Dr. Nooth's glaſs apparatus for impregnating water with carbonic acid gas, the quantity of gas that can be thrown into it is very moderate, yet efficacious; but the ſoda water which is now prepared and ſold in London by a Mr. Schweppe, contains an incomparably greater proportion of carbonic acid gas, and accordingly is much more efficacious.

The like treatment is ſaid to have been found ſometimes uſeful in ſcrophulous tumours.

Ulcers.

THE factitious airs have been frequently adminiſtered in caſes of ulcers on different parts of the body, and eſpecially on the legs; but the indiſcriminate and injudicious application, which ſeems evident in many caſes, has been productive of equivocal effects. However, a careful examination of the particular circumſtances ſhews, in agreement with the theory, that when the ulcers originate from a poor ſtate of the blood, and a debilitated habit, the daily inhalation of three or four pints of oxygen air, with about ten times that quantity of common air, is of ſingular uſe; and by this means ſome ulcers of the worſt kind, *viz.* painful, fœtid, ſtubborn, &c. and when they were accompanied with ſcurfy eruptions over great part of the body, with want of appetite, &c. have been completely cured in about ſix weeks time.

IN ulcers of other ſort the ſtate of the patient, as alſo the origin of the diſorder, muſt be carefully attended to, and the elaſtic fluids, when they may be thought uſeful, muſt be adminiſtered accordingly, otherwiſe they will produce more harm than good. In fact, I find a caſe of a ſcrophulous ulcer, where the oxygen air proved detrimental; but a mixture of oxygen, hydrocarbonate, and common air, accompliſhed the cure. This caſe will be found in the next chapter.

IN all caſes of ulcers, the external application of carbonic acid gas generally affords an alleviation of pain, as well as of the fœtor, and a better diſcharge.

CHAPTER VIII.

Medical Caſes in which Aerial Fluids were adminiſtered.

A COLLECTION of medical caſes, in which the factitious airs have been adminiſtered with great ſucceſs, forms the content of the preſent chapter. Thoſe caſes have been either extracted from other publications, or they have been communicated by intelligent friends; and they have been ſelected out of a great number, merely for the purpoſe of ſhewing the practical methods of adminiſtering the artificial elaſtic fluids. Such caſes, therefore, have been preferred, as by the variety of circumſtances ſeemed more likely to manifeſt the modes of applying, proportioning, varying, and ſuſpending the adminiſtration of the factitious airs.

CONVINCED that the unſkilful application of this new ſet of remedies has produced conſiderable harm, and has thrown a degree of diſcredit on the practice, I take the liberty of warning the practitioners againſt drawing haſty concluſions from a few crude, and, in all probability, ill-managed caſes. For however ſkilled thoſe gentlemen may be in other branches of phyſic, it is at leaſt likely that in this new application their management of patients may not be generally correct; and of courſe the failure is not always to be attributed to the want of power in the aerial fluids.

CASE I.

Communicated by Dr. J. Lind, of Windſor.

THE firſt time I applied the modified atmoſphere as a remedy, was in the caſe of an officer of the Exciſe, who, during the ſevere weather of January, 1797, being much expoſed to the cold in the exerciſe of his duty, had got a violent cough, which cauſed the rupture of a conſiderable blood veſſel in his lungs, and this was ſoon followed by the ſymptoms of a rapid conſumption. On the 25th of January he firſt applied to me, when I ordered him an infuſion of roſes, acidulated with vitriolic acid, and ſmall doſes of ipecacuanha, to ſtop the hœmoptoe; and for the cough and hectic fever I recommended him to breathe, ſeveral times in the courſe of the day, the vapour of vitriolic ether, in which the powdered leaves of *cicuta* were infuſed, after the manner recommended by Dr. Pearſon, of Birmingham. The benefit which he received from this application was really remarkable, for after not more than four or five days, almoſt all the bad ſymptoms were wonderfully diminiſhed; yet, finding that he got hardly any ſleep at night, and that he had been a bad ſleeper for above a year, I made him inhale about a quart of hydrocarbonate gas, diluted with about fourteen quarts of common air, at bed-time, which procured him an uninterrupted night's reſt, ſuch as he had not experienced for many months before. He continued to follow the ſame courſe till the 20th of February, when his health being perfectly reſtored, he returned to his duty.—N. B. When he inhaled the diluted hydrocarbonate, he drew it in over the ſteam of hot water, with the inhaler which I have conſtructed on the plan of Mr. Watt's refrigeratory *.

CASE II.

Communicated by the ſame.

I TRIED the diluted hydrocarbonate likewiſe with ſucceſs, in an inflammation of the lungs. The patient was a man of ſixty-ſix years of age, labouring under an inflammation of the lungs, but attended with ſo ſmall a pulſe that bleeding did not appear adviſeable. I therefore directed him to breathe the hydrocarbonate gas, diluted nearly in the proportion mentioned in the preceding caſe, which he did every night, and occaſionally whenever the pain returned. The effect of the modified air was immediate, and very remarkable, for not only the pain was removed, but he uſed to ſay that the hydrocarbonate had deprived him of his body, and had left him only his head; ſuch was the diminution of irritability which this gas is capable of producing.

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* This inhaler is made of japanned tin, and being filled with hot water, is interpoſed between the bag or receiver of air and the mouth of the patient, ſo that the air is heated by the vapour of hot water in paſſing through it.

THE diſorder vaniſhed in a very ſhort time: for in ſeven days from the commencement of the application, his health was perfectly reſtored.

THIS caſe ſhews that in inflammations of the lungs, when the pulſe is weak, which is ſometimes the caſe, the reduced atmoſpheres are, perhaps, the only application practicable.

CASE III.

Related by Dr. Carmichael.

Birmingham, March, 1795.

I. B. æt. 45, was attacked about four months ſince with difficulty of breathing, attended at times with pain under the ſternum, and commonly with a ſenſe of tightneſs of the thorax, frequent cough, with copious expectoration of a tough whitiſh fluid, pulſe 96, body regular, appetite variable. He has ſeldom paſſed four and twenty hours without a material aggravation of all his ſymptoms. Was firſt attacked with this diſorder ſix years ago, and has regularly ſuffered very ſeverely from it every winter ſince that period; it has always left him about the beginning of May, and he has kept free from complaint during the ſummer and autumn months. He has tried many remedies, but never with more than very tranſitory relief.

FEBRUARY 14th, 1795, I directed him to inhale daily a mixture of hydrocarbonate and atmoſpheric air, in the proportion of 1 to 19.—15th, No ſenſible effects from the uſe of the hydrocarbonate; the ſtrength of the mixture was therefore increaſed in the proportion of two to 18.—16th, No vertigo, nor any other ſenſible effect, produced by the uſe of the modified air. The proportion ſtill farther increaſed to 4 to 18.—17th, Conſiderable vertigo produced by yeſterday's doſe, which returned at intervals, attended by head-ach during the day. Breathing much relieved, even during the act of inhaling the modified air, and has ſince continued tolerably eaſy. Slept better laſt night than he has been accuſtomed to do for ſome months.—22d, Hydrocarbonate continues to produce conſiderable giddineſs; breathing, except ſome ſhort intervals of ſlight return, continues much eaſier. Cough leſs frequent, expectoration much diminiſhed. Continues to enjoy comfortable ſleep.—27th, Had a conſiderable return of difficulty of breathing on the afternoon of the 25th, which, however, abated ſo much before his uſual bed-time, as not to prevent him from paſſing the night comfortably. Cough infrequent, and rarely attended with expectoration. Has for ſome time paſt had no pain under his ſternum, and rarely any ſenſe of tightneſs of his thorax. —March 4th, He is in every reſpect ſo much better, that he intends to return to his uſual occupation (making moulds in a caſt-iron foundry) on the 9th inſt. Modified air continues to produce vertigo.—March 9th, He continued without any return of his complaint, and returned to his employment as he intended; but after working for a few hours only, he was obliged to deſiſt, by a return of the ſenſe of tightneſs on his thorax, and conſiderable difficulty of breathing. Breathing increaſed in difficulty towards evening, and ſtill continues, attended by frequent dry cough.—13th, Continues to breathe with conſiderable difficulty, pulſe 100; ſleepleſs nights; cough more frequent, but now attended with conſiderable expectoration.—17th, Difficulty of breathing continued until yeſterday; has paſſed a better night than uſual; and this morning finds himſelf much better.—20th, Breathing continues eaſier; cough much leſs frequent, and quantity of expectoration diminiſhed. Has ſlept for ſome nights paſt comfortably; pulſe 86. Modified air continues to produce conſiderable vertigo.—29th, Continues uniformly to recover; his cough is very trifling, and he expectorates better; his ſtrength is ſo much improved, that he can uſe conſiderable exerciſe without inconvenience. Sleeps uniformly well.—He returns to his work to-morrow, but for the preſent is to work within doors. He is of opinion that he is in every reſpect equal to the undertaking.

CASE IV.

Related by the ſame.

J. T. æt. 40. has for two years paſt been affected, during the winter and ſpring months, with cough and expectoration, and at times with pains in his breaſt, accompanied with ſlight dyſpnœa. Theſe ſymptoms,

toms, in general, left him during the ſummer months, and never at any time aroſe to ſuch a degree as to prevent him from following his uſual occupation. In the beginning of October laſt he was ſeized with pain on his ſide, cough, dyſpnœa, and after ſome time with copious expectoration. He applied for my advice in the beginning of November. At that time he had an almoſt inceſſant cough, attended with copious expectoration; he complained of a ſenſe of tightneſs acroſs his thorax, and much dyſpnœa on the ſlighteſt exertion; his pulſe was in general from 110 to 120, his nights were reſtleſs, and attended with profuſe perſpirations, his body was irregular, his appetite much impaired, his frame much emaciated. I ordered for him, at different times, emetics, ſquills, ammoniacum, bliſters, &c. but from none of them did he derive more than a very temporary relief.—November 27th, he began the uſe of the hydrocarbonate; I directed him at firſt to inhale a mixture containing a quart and a half of this ſpecies of factitious air, and nineteen of atmoſpheric air. This quantity he uſed in about twenty minutes, breathing it for twenty ſeconds together, and then reſting for one, two, or three minutes, according to the degree of vertigo produced. —28th, The vertigo produced by yeſterday's inhalation was very ſevere, and returned at intervals during the evening. He has paſſed a much better night than uſual, and ſays that the dyſpnœa and ſenſe of ſtricture on the thorax are much relieved. The quantity of hydrocarbonate diminiſhed to one quart, diluted as above.—30th, Cough much relieved, ſenſe of ſtricture gone, dyſpnœa leſs troubleſome on motion, has had better nights, and his perſpirations are leſs profuſe; pulſe 106, appetite rather better.—December 7th, Cough evidently better, expectoration conſiderably diminiſhed, pulſe 95, body for ſome days paſt regular; breathing ſo much improved that he can with eaſe walk up ſtairs to his chamber and undreſs himſelf, without return of diſpnœa, which he could not before accompliſh without the greateſt difficulty; ſleeps better than he has done for months paſt, perſpirations entirely left him, appetite mended.—15th, Continues to recover in every reſpect, has at times ſome return of tightneſs on his breaſt, but which is uniformly relieved or completely carried off by the hydrocarbonate. His countenance is evidently altered for the better, and he is of opinion that his ſtrength returns. Notwithſtanding that the modified air ſtill continues to produce conſiderable vertigo, I increaſed the quantity to two quarts, diluted as before.—27th, Cough very much relieved, expectorated matter reduced to one-third of its former quantity, pulſe from 84 to 90. He has evidently acquired fleſh, and he is of opinion that his ſtrength continues to improve.—January 6th, 1795, Cough rather more frequent, and attended with ſome degree of diſpnœa. On account of the ſeverity of the weather, which evidently affects him, I ordered him not to ſtir from home. At this time he began to breathe the modified air, of the ſtrength directed above, twice a day.—16th, Cough relieved, quantity of expectorated matter much the ſame as reported on the 27th ult.; in other reſpects the ſame.—February 1ſt, On account of the unuſual ſeverity of the weather, no advance has been made ſince laſt report. Cough more variable, and at times attended with ſome degree of diſpnœa, expectorated matter increaſed, he does not, however, emaciate. —12th, Cough much abated, quantity of expectoration reduced to one-fifth of its former quantity, his ſtrength is ſo much recruited that it is with difficulty I can reſtrain him from returning to his occupation. In every reſpect he is much better.—March 1ſt, continues to gain ſtrength, cough leſs frequent, and expectoration ſtill diminiſhing in quantity, appetite good, ſleeps well. As I could not prevail with him to remain longer at home, I adviſed him, before he returned to his uſual occupation, to walk out a little daily.

HE complied with my advice, and continued to gain ground till the 9th of that month, when in the evening he was ſeized with the uſual ſymptoms of the influenza, an epidemic catarrhal infection, which at that time prevailed much in this place. The febrile ſymptoms ran high, and were attended by frequent cough and conſiderable pain on his ſide; he complained alſo of ſevere head-ach, and unuſual langour; he was thirſty; his tongue was white, and his pulſe 110.—March 15th, febrile ſymptoms continue; cough frequent, but now attended with increaſed expectoration; pain of his ſide leſs ſevere; conſiderable diſpnœa on the ſlighteſt motion; pulſe 115, ſmall and weak. Until this attack he inhaled twice daily a gallon of hydrocarbonate, diluted with four times the quantity of atmoſpheric air, but, as his ſtrength waſted, it was found neceſſary to leſſen the quantity to one quart diluted as above.—March 20th, pain of his ſide ſomething eaſier, but his cough is increaſed in frequency, and his expectoration more copious. Reſtleſs nights; no appetite; ſtrength ſo much impaired that, for the laſt four days, he has not been able to inhale the modified air; pulſe 120.

I directed a warm ſtimulating plaiſter to be applied to his ſide, and five drops of tinctura opii to be given every four hours.—March 28th, pain of his ſide gone, but his other ſymptoms continue; bowels regular; has had better nights, but his ſleep has been attended with profuſe perſpirations; the tinctura opii was omitted, and he was directed to take at nearly the ſame intervals a ſmall glaſs full of port wine.—April 15th, complaints continue without material alteration. From this date he re-commenced the uſe of the hydrocarbonate, beginning with it of the ſtrength of one pint to ſixteen quarts of common air.—April 25th, at firſt the modified air occaſioned conſiderable vertigo, but he ſoon became ſo much habituated to its operation that the quantity was increaſed to one, and afterwards to two, quarts. His perſpirations have abated, his cough has been leſs urgent, the quantity of his expectoration has diminiſhed, and the diſpnœa, with which he has for ſome time paſt been troubled on the ſlighteſt motion, is greatly alleviated.

MARCH 3, Since the laſt report he has experienced conſiderable amendment, pulſe 98. The quantity of hydrocarbonate was further increaſed to a gallon, diluted with four times that quantity of atmoſpheric air. May 15th, he has continued to recover ſo much in every reſpect, that yeſterday he was able to walk fourteen miles into the country.

FROM this time I did not ſee him till the middle of June, when he returned to this place with an intention to follow his uſual occupation. He was in every particular ſo much better, that he ſeemed to have recovered his health completely. I adviſed him, however, to the contrary, to which he conſented, and he has ſince been occupied in hay-making, and more lately in reaping. I ſaw him a few days ago; he cannot be ſaid either to cough or expectorate, except in the morning, and then in the moſt trifling degree, and his ſtrength is ſo completely reſtored, that he has been earning wages equal to thoſe of the ſtouteſt of his fellowlabourers, with both eaſe to himſelf and ſatisfaction to his employer.

CASE V.

Related by Dr. W. Pearſon.

ELIZABETH VYSE, aged 27, having been ſeized at the end of autumn with cough, fever, and ſpitting of blood, applied at the hoſpital for relief, and came under my care laſt October. She informed me ſhe had been ſubject to a cough for three winters. She had a quick and ſmall pulſe, fluſhed cheeks, dyſpnœa, pain on the ſide, conſtant cough attended with copious expectoration, and night-ſweats. She was very feeble and much emaciated. The hæmoptoe was ſoon removed by the medicines commonly preſcribed in ſuch caſes; but the ſymptoms continued. I therefore ordered her, on the 12th of November, to breathe the vapour of vitriolic æther, impregnated with extract of cicuta two or three times a day. On the 19th, when I ſaw her again, ſhe informed me that ſhe had obtained great relief from the æther vapour, having much leſs tightneſs acroſs the cheſt, and leſs pain of the ſide. She ſaid ſhe was ſomewhat giddy after every inhalation.—December the 3d, leſs fever, leſs cough, and conſiderably better in every reſpect. Has found more benefit (to uſe her own words) from the æther application than from any thing elſe.—December 10th, cough and other complaints ſo ſlight, that ſhe ſays ſhe does not require any more medicines.

N. B. During the uſe of æther vapour, ſhe took a decoction of Peruvian bark and ſarſaparilla, and pills compoſed of extract of cicuta and rhubarb.

CASE VI.

Related by Mr. Barr. Birmingham, October 9, 1795.

MR. BARROR, of Barton-under-Needwood, being in this town on a viſit to a friend in the ſpring of 1793, was ſeized with an highly inflammatory fever, attended with a violent pain of the ſide. This fever was followed by a dry tickling cough, a ſenſe of tightneſs in breathing, much languor, and a great degree of reſtleſſneſs and anxiety. His bowels felt full, tenſe, and uneaſy; his pulſe intermitted; and he complained that his urine, though nearly in the uſual quantity, did not flow freely, and that he had always the ſenſation of not having evacuated the whole. Bliſters, boluſſes of triturated mercury, and a decoction firſt of Peruvian, and afterwards of Anguſtra, bark were preſcribed. He was relieved by theſe medicines, but he neither recovered his ſtrength nor his ſpirits. In this ſituation nearly he paſſed the remainder of the year in the country; in the ſpring of 1794 he came to Birmingham again, with all the ſymptoms of his diſorder increaſed, particularly the oppreſſion in breathing. He could neither lie down in bed with comfort, nor aſcend the ſmalleſt aclivity without the greateſt uneaſineſs. His urine was diminiſhed in quantity, and voided with difficulty. A decoction of Seneka root, and ſmall doſes of Digitalis were directed and continued for two or three weeks; but they rather ſeemed to amuſe than relieve him. He called on me again laſt April, and told me that all medicines had loſt the power of relieving him, that his breathing was now more generally difficult, that his urine was very ſcanty, and that his appetite was entirely gone. I preſcribed the Digitalis with a bitter infuſion. He went into the country and continued theſe medicines for ſome time. Towards the end of July he called upon me again—but, alas! how changed! His face was now become pale and emaciated, his eyes ſtared as if taking a laſt conſcious view of their object; which laſt circumſtance much alarmed his friends.—His legs were ſwelled to ſuch a degree that the ſkin was become much inflamed, and in danger of burſting. He had a continual teneſmus, and made very little urine; he could not endure an horizontal poſture for a moment, but was under the neceſſity of being bolſtered upright in bed through the night; even then he ſlept little, and that little was diſturbed and unrefreſhing, for he frequently ſtarted from his ſleep under an impreſſion of inſtant ſuffocation.

HAVING ſeen an account of the happy relief Sir William Chambers had experienced from oxygen in a ſimilar ſituation, I wrote to my patient, and adviſed the adoption of the pneumatic plan. I did this, I confeſs, in the preſent inſtance, with little hope of advantage; but as the moſt powerful medicines had produced no ſalutary effect, I felt it my duty to him, as well as to the cauſe of humanity, to urge this compliance. I procured him a reading of the caſe, and the ſimilarity of the circumſtances was ſo ſtriking, that he agreed to place himſelf immediately under my care.

HE arrived here on the 12th of Auguſt, and began to inſpire the factitious air on the 13th. I directed one quart of oxygen mixed with nineteen of atmoſpheric air, to be inhaled every day; but as the ſymptoms were become extremely urgent, I thought it right to join the uſe of thoſe active medicines that I had preſcribed for him before. Accordingly I directed him to take half a grain of Digitalis in ſubſtance, every evening, and four ounces of a decoction of Anguſtra bark in the courſe of each day. On the third night after inſpiring he found himſelf more compoſed, he could remain longer in one poſture, and the ſtartings, during ſleep, ſeemed both leſs frequent and leſs violent. Every night he was ſenſible of amendment; in ten days he could bear the removal of ſeveral of the pillows that bolſtered him up in bed; and he could ſleep for three or four hours without one ſtarting fit. The ſwelling of his legs too began now to ſubſide; the teneſmus was entirely removed; the quantity of urine was much increaſed, and he could walk up ſtairs with much eaſe; his appetite and cheerfulneſs began to return, and the pale face of diſeaſe to give place to the florid countenance of health. In the courſe of the ſecond week I had gradually increaſed the quantity of oxygen to two quarts a day, diluted as before.

fore. In four weeks from his beginning to inſpire the vital air, not a veſtige of the diſorder remained, except weakneſs; he could lay his head as low in bed as when in perfect health, and ſleep the whole night; no ſwelling of the legs remained; no difficulty of breathing upon ordinary exertion; and every function was performed with regularity and eaſe. He then went home provided with a pneumatic apparatus, and directions how to uſe it, and laid aſide the uſe of all medicines except a laxative pill occaſionally. He paſſed through this town yeſterday in perfect health. His ſtrength, agility, and vivacity, are greater than in moſt men of his age (60).

CASE VII.

Related by Dr. Alderſon.—Hull, June 5th, 1795.

MISS ——, aged 16, had all the ſymptoms of approaching phthiſis, cold tremors about twelve o'clock; fever, heat, and fluſhing

ing every afternoon, pulſe 120, countenance uncommonly florid, breathing rather difficult, cough ſevere, accompanied with expectoration; as ſeveral of her family had died of conſumption, there could be little doubt of the tendency of theſe ſymptoms; and after finding nitre, ſpermaceti, vomits, &c. to have no good effect, I adviſed the inhalation of hydrogen air. She therefore daily inhaled a quart of pure hydrogen from water, by every now and then taking an inſpiration at the mouth-piece of the tunnel. It frequently occaſioned nauſea and even vomiting. The pulſe fell, the fluſhings and fever ſubſided, and the whole train of phthiſical ſymptoms left her, but at the expence of her fine florid colour, her countenance having ever ſince been of a darker tint than before ſhe was ill.

CASE VIII.

Related by Mr. Barr.—Birmingham, 14*th March* 1795.

ABOUT four months ago, a gentleman of this neighbourhood applied to me for advice in the management of a ſcrophulous ulcer of conſiderable extent. He had tried various remedies, but had derived no laſting advantage from any of them. When I firſt viſited him he was worn down by a long courſe of night-watching. The deep-ſeated pain of the arm was ſo conſtant and ſevere, that it had in great meaſure deprived him of ſleep. His countenance was pale and ſickly; his limbs were continually afflicted with aching pains; every exertion, even the moſt gentle, ſeemed beyond the meaſure of his ſtrength, for his body had loſt much of its active power, and his mind much of its wonted energy. The diſcharge from the ulcer was copious, thin, bloody, and corroſive; and beſides, the whole ſurface of the ſore was ſo exceedingly irritable, that the mildeſt dreſſings, applied in the gentleſt manner, produced very ſevere and laſting pain. During the firſt ſix weeks of my attendance, he regularly took as much Peruvian bark in ſubſtance as his ſtomach and bowels could bear; and the ulcer was dreſſed with various emollient, ſedative, and aſtringent applications, but without any permanent advantage. I then recommended a trial of oxygen air, which was readily complied with. He began by inſpiring four ale quarts diluted with ſixteen of atmoſpheric air twice a day, and gradually increaſed the quantity of oxygen to a cubic foot and a half in the day; by purſuing this plan for about a month, his health was wonderfully improved, but the ulcer ſhewed no diſpoſition to heal. The deep-ſeated pain was now entirely removed, but in the ſpace of a few days more he complained of a burning ſenſation over the whole ſurface of the ſore, ſimilar to the pain ariſing from eriſepelatous inflammation. This unpleaſant ſenſation firſt commenced after inſpiring the whole quantity of oxygen in the ſpace of two hours, which before had been taken in equally divided portions morning and evening. We ſtill purſued our plan, thinking that this new pain might be owing to ſome accidental circumſtance, and that it would ſoon paſs away. But it every day continued to increaſe, and the ulcer began to ſpread wider and wider. The edges became thick, and were turned outwards, and the diſcharge became more thin and acrid.

IN this ſituation a local application ſeemed proper. I wiſhed to have applied hydrocarbonate externally to the ulcer, but this, from ſome circumſtance of the caſe, was not practicable. I then thought to moderate the ſtimulus of the oxygen by a mixture of hydrocarbonate, which Mr. Watt told me would occaſion no chemical change in the two airs. Accordingly a mixture of three parts of oxygen, and one of hydrocarbonate, was preſcribed. Four quarts of this mixed air were added to about ſixteen of atmoſpheric,

ric, and this quantity inſpired morning and evening. In leſs than a week the burning ſenſation was much diminiſhed, and the ulcer put on a more healing appearance. The mixed air was then increaſed to five quarts, and uſed as before, which produced an increaſe of all the pleaſant ſymptoms. After a few days trial of this proportion of the mixed air ſix quarts were preſcribed. This is the quantity now inſpired morning and evening.

MY friend, at preſent, enjoys good health and a good appetite, and feels himſelf as ſtrong as at any former period of his life. The ulcer is now reduced to leſs than half its original ſize, and healing rapidly. There is neither ſuperficial nor deep-ſeated pain remaining, and the action of the contiguous muſcles is free and eaſy.

CASE IX.

Related by Dr. Redſearn, Lynn, Norfolk,
June 26, 1795.

MR. B. F—— æt. 23, of a florid complexion, narrow cheſt, prominent ſhoulders, ſmooth ſkin, and of a delicate ſlender form, has been afflicted with hæmoptyſis about two years and a half, attended with dyſpnœa, cough, a diſagreeable ſenſe of burning in the cheſt, and expectoration of a purulent nature. Pulſe about 100, and invariably accelerated by the hydrocarbonate air. The hectic fever was not completely formed, but he had at times a ſenſe of chillineſs in the day-time, with heat towards the evening. He began by taking one quart of hydrocarbonate, diluted with twenty-one quarts of atmoſpheric air, once a day. From this mixture he experienced much vertigo during its inhalation, and two hours after dinner he ſuddenly became vertiginous, from which, however, he ſoon recovered, although a violent head-ach remained during the reſt of the evening.

THE following days he only inhaled one pint of hydrocarbonate mixed with twenty quarts of common air, once a day, which generally affected him with ſome ſlight vertigo and tightneſs over his forehead; the hydrocarbonate was increaſed gradually to two quarts or more at one doſe, but I find it always neceſſary to begin with the original doſe, where the air has been recently generated.

MY patient has been perſevering in this plan about three months, and has had no return of the hæmorrhage; his cough and expectoration are very much diminiſhed; ſometimes he does not expectorate more than one table-ſpoonful in the ſpace of three days; he has alſo never experienced any of the diſtreſſing heats in his cheſt, which haraſſed him before the adminiſtration of the air; his dyſpnœa is perfectly removed; he can ride upon horſeback twelve miles without feeling much fatigue; his appetite is very good, and he ſleeps well; pulſe 80; he ſays he thinks his health is perfectly eſtabliſhed.

Case X.

IN the month of June 1797, a lady began the uſe of vital air, for an entire loſs of voice, which misfortune ſhe had ſuſtained about three years. Her conſtitution was extremely nervous; had been the greateſt part of her life ſubject to deplorable ſpaſmodic affections, particularly in the organs of reſpiration, on any trifling exertions of exerciſe, or in a confined atmoſphere; ſhe had been long habituated to an uncommon quantity of opium, to ſuſpend the frequency and violence of her attacks, and many means had been tried in vain to diminiſh materially the quantity ſhe found neceſſary for her ſupport.

She commenced the uſe of the vital air under the diſadvantage of remaining in

London during the ſummer, a circumſtance which was likely to be attended with great aggravation of her complaints, being contrary to her uſual practice, and, in fact, ſhe had already begun to experience extraordinary ſymptoms of debility from the attempt.

ABOUT three quarts of oxygen, with twelve quarts of common air, were adminiſtered daily for about a fortnight, the effect of which was, that a ſlight degree of tightneſs about her cheſt came on ſoon after the inhalation of the air, and generally went off in five or eight minutes time; the pulſe was likewiſe rendered fuller though not more frequent, and the nights were often attended with a ſort of reſtleſſneſs. In conſequence of this laſt effect it was judged proper to diminiſh the quantity of oxygen air, and accordingly it was found, after repeated augmentations and diminutions of the doſe, that about one quart or three pints of oxygen air, with about twelve quarts of common air, was the proportion of the aerial fluids, which ſeemed to agree beſt with her conſtitution. This application was perſiſted in for upwards of five months, excepting ſome ſlight intermiſſions of a day or two occaſionally, and it produced the moſt ſalutary effects. The whole habit of body began to be improved in about a month after the commencement of the application. The ſhortneſs of breath vaniſhed gradually, as alſo the ſymptoms of debility. Her aſpect became healthy, and the voice improved by ſlow degrees, ſo that by the end of October its tone was become fully equal to what it uſed to be previouſly to the illneſs. In ſhort, this lady now enjoys a better ſtate of health than ſhe has experienced for many years.

A REMARKABLE circumſtance was obſerved in this caſe with reſpect to the effect of opium, which is, that from long habit ſhe had accuſtomed herſelf to take an extraordinary quantity of opium daily, in order to ſuſtain her uſual exertions of the day; for, in fact, the opium produced in her rather a ſerenity of ſpirits than drowſineſs; but after having inhaled the oxygen air for a few days, ſhe found that ſhe could do with leſs opium, and in proceſs of time ſhe further obſerved, that the opium, inſtead of ſupporting, diſcompoſed her ſo much as to oblige her to diminiſh the quantity of it to a very ſmall part of what ſhe had been accuſtomed to take before the uſe of the oxygen air.

CASE XI.

Related by Mr. Hey, in a Letter to Dr. Prieſtley.

January 8th, MR. LIGHTBOWNE, a young gentleman who lives with me, was ſeized with a fever, which, after continuing about ten days, began to be attended with thoſe ſymptoms that indicate a putreſcent ſtate of the fluids.

18th. HIS tongue was black in the morning when I firſt viſited him, but the blackneſs went off in the day-time upon drinking; he had begun to doze much the preceding day, and now he took little notice of thoſe that were about him; his belly was looſe, and had been ſo for ſome days; his pulſe beat 110 ſtrokes in a minute, and was rather low; he was ordered to take twenty-five grains of Peruvian bark with five of tormentill-root in powder every four hours, and to uſe red wine and water, cold, as his common drink.

19th. I WAS called to viſit him early in the morning, on account of a bleeding at the noſe which had come on; he loſt about eight ounces of blood, which was of a looſe texture; the hæmorrhage was ſuppreſſed, though not without ſome difficulty, by means of tents made of ſoft lint dipped in cold water ſtrongly impregnated with tincture of iron, which were introduced within the noſtrils quite through to their poſterior apertures, a method which has never yet failed me in like caſes. His tongue was now covered with a thick black pellicle,

which

which was not diminiſhed by drinking; his teeth were furred with the ſame kind of ſordid matter, and even the roof of his mouth and fauces were not free from it; his looſeneſs and ſtupor continued, and he was almoſt inceſſantly muttering to himſelf; he took this day a ſcruple of the Peruvian bark with ten grains of tormentill every two or three hours; a ſtarch clyſter, containing a drachm of the compound powder of bole, without opium, was given morning and evening; a window was ſet open in his room, though it was a ſevere froſt, and the floor was frequently ſprinkled with vinegar.

20th, HE continued nearly in the ſame ſtate; when rouſed from his dozing, he generally gave a ſenſible anſwer to the queſtions aſked him, but he immediately relapſed, and repeated his muttering. His ſkin was dry and harſh, but without *petechiæ*. He ſometimes voided his urine and *fæces* into the bed, but generally had ſenſe enough to aſk for the bed-pan. As he now nauſeated the bark in ſubſtance, it was exchanged for Huxham's tincture, of which he took a table-ſpoonful every two hours in a cup full of cold water; he drank ſometimes a little of the tincture of roſes, but his common liquors were red wine and water, or rice-water and brandy acidulated with elixir of vitriol; before drinking he was commonly requeſted to rinſe his mouth with water, to which a little honey and vinegar had been added. His looſeneſs rather increaſed, and the ſtools were watery, black, and fœtid; it was judged neceſſary to moderate this diſcharge, which ſeemed to ſink him, by mixing a drachm of the *theriaca andromachi*, with each clyſter.

21ſt, THE ſame putrid ſymptoms remained, and a *ſubſultus tendinum* came on; his ſtools were more fœtid, and remarkably hot; the medicine and clyſters were repeated.

REFLECTING upon the diſagreeable neceſſity we ſeemed to lie under of confining this putrid matter in the inteſtines, leſt the evacuation ſhould deſtroy the *vis vitæ* before there was time to correct its bad quality, and overcome its bad effects, by the means we were uſing, I conſidered that, if this putrid ferment could be more immediately corrected, a ſtop would probably be put to the flux, which ſeemed to ariſe from, or at leaſt to be increaſed by it, and the *ſomes* of the diſeaſe would likewiſe be in a great meaſure removed; I thought nothing was ſo likely to effect this as the introduction of fixed air into the alimentary canal, which, from the experiments of Dr. Macbride, and thoſe you have made ſince his publication, appears to be the moſt powerful corrector of putrefaction hitherto known. I recollected what you had recommended to me as deſerving to be tried in putrid diſeaſes; I mean the injection of this kind of air by way of clyſter, and judged that in the preſent caſe ſuch a method was clearly indicated.

THE next morning I mentioned my reflections to Dr. Hird and Dr. Crowther, who kindly attended this young gentleman at my requeſt, and propoſed the following method of treatment, which, with their approbation, was immediately entered upon. We firſt gave him five grains of ipecacuanha, to evacuate, in the moſt eaſy manner, part of the putrid *colluvies*; he was then allowed to drink freely of briſk orange-wine, which contained a good deal of fixed air, yet had not loſt its ſweetneſs. The tincture of bark was continued as before, and the water, which he drank along with it, was impregnated with fixed air from the atmoſphere of a large vat of fermenting wort, in the manner I had learned from you. Inſtead of the aſtringent clyſter, air alone was injected, collected from a fermenting mixture of chalk and oil of vitriol: he drank a bottle of orange-wine in the courſe of this day, but refuſed any other liquor, except water and his medicine; two bladders full of fixed air were thrown up in the afternoon.

23d, HIS ſtools were leſs frequent; their heat likewiſe, and peculiar *fœtor*, were conſiderably diminiſhed; his muttering was much abated, and the *ſubſultus tendinum* had left him. Finding that part of the air was rejected when given with a bladder in the uſual way, I contrived a method of injecting it which was not ſo liable to this inconvenience. I took the flexible tube of that inſtrument which is uſed for throwing up the fume of tobacco, and tied a ſmall bladder to the end of it that is connected with the box made for receiving the tobacco, which I had previouſly taken off from the tube; I then put ſome bits of chalk into a ſix-ounce phial until it was half filled; upon theſe I poured ſuch a quantity of oil of vitriol as I though capable of ſaturating the chalk, and immediately tied the bladder, which I had fixed to the tube, round the neck of the phial; the clyſter-pipe, which was faſtened to the other end of the tube, was introduced into the *anus* before the oil of vitriol was poured upon the chalk. By this method the air paſſed gradually into the inteſtines as it was generated, the rejection of it was in a great meaſure prevented, and the inconvenience of keeping the patient uncovered during the operation was avoided.

24th, HE was ſo much better that there ſeemed to be no neceſſity for repeating the clyſters; the other means were continued. The window of his room was now kept ſhut.

25th, ALL the ſymptoms of putreſcency had left him; his tongue and teeth were clean; there remained no unnatural blackneſs or *fætor* in the ſtools, which had now regained their proper conſiſtence; his dozing and muttering were gone off, and the diſagreeable odour of his breath and perſpiration was no longer perceived. He took nouriſhment to-day with pleaſure, and, in the afternoon, ſat up an hour in his chair.

HIS fever, however, did not immediately leave him; but this we attributed to his having caught cold from being incautiouſly uncovered when the window was open, and the weather extremely ſevere; for a cough, which had troubled him in ſome degree, from the beginning, increaſed, and he became likewiſe very hoarſe for ſeveral days, his pulſe at the ſame time growing quicker; but theſe complaints alſo went off, and he recovered, without any return of the bad ſymptoms above-mentioned.

CASE XII.

Related by Dr. Thomas Percival.

ELIZABETH GRUNDY, aged ſeventeen, was attacked, on the 10th of December, with the uſual ſymptoms of a continued fever. The common method of cure was purſued, but the diſeaſe increaſed, and ſoon aſſumed a putrid type.

ON the 23d, I found her in a conſtant delirium, with a *ſubſultus tendinum*. Her ſkin was hot and dry, her tongue black, her thirſt immoderate, and ſtools frequent, extremely offenſive, and for the moſt part involuntary. Her pulſe beat 130 ſtrokes in a minute; ſhe doſed much, and was very deaf. I directed wine to be adminiſtered freely; a bliſter to be applied to her back; the *pediluvium* to be uſed ſeveral times in the day, and fixed air to be injected under the form of a clyſter every two hours. The next day her ſtools were leſs frequent, had loſt their fœtor, and were no longer diſcharged involuntarily; her pulſe was reduced to 110 ſtrokes in the minute, and her delirium was much abated. Directions were given to repeat the clyſters, and to ſupply the patient liberally with wine. Theſe means were aſſiduouſly purſued ſeveral days, and the young woman was ſo recruited by the 28th, that the injections were diſcontinued. She was now quite rational, and not averſe to medicine. A decoction of Peruvian bark was therefore preſcribed, by the uſe of which ſhe ſpeedily recovered her health.

CASE XIII.

Communicated by an intelligent Gentleman in the Weſt of this Iſland.

A YOUNG lady of 18, the daughter of a neighbour of mine, had been long indiſpoſed with a ſort of diſorder which the medical gentlemen of the neighbourhood could neither properly define, nor in the leaſt relieve. The origin of this indiſpoſition is attributed to a violent cold, which this young lady caught about two years ago at a ball; for ſince that time ſhe had never enjoyed her health, and, in ſpite of all medicines, ſhe rather loſt ground by ſlow degrees than ſhewed any appearance of amendment. The ſymptoms, as nearly as I can deſcribe them, were as follows:

SHE had loſt all colour from her face and hands, had a remarkably keen appetite, and eat much more than other perſons of her age are wont to do; but this food gave her neither ſtrength nor increment, and ſhe conſtantly complained of wearineſs, refuſing to take any ſort of exerciſe. At night ſhe frequently had a ſlight fever, which terminated by the morning with an head-ach; but this fever did not come on every night, nor did it ſeem to follow any determinate period. She perſpired profuſely every night, and even in the day-time the leaſt exertion would throw her into a profuſe perſpiration. She had tried bark, ſteel medicines, mineral waters, ſlight emetics, rhubarb, &c. but all in vain.

In this ſtate of things I firſt took the liberty of recommending the uſe of the vital air, or oxygen air, concerning which much has been ſaid of late, and to the phyſical properties of which I had two years ago been witneſs in a courſe of chemical lectures, which I attended in London. After ſeveral converſations with the father of the young lady on the ſubject, it was at laſt agreed to try the oxygen air, and I undertook to perform the experiment with a few chemical veſſels which I happened to have by me.

ON the tenth of April, 1797, I put eight ounces of nitre in a ſmall and luted green glaſs retort, and by expoſing the retort to a barely red heat, I obtained nearly two quarts meaſure of oxygen air, which, being mixed with about eight quarts of common air, was given to the young lady in an awkward manner; for it was introduced into an old glaſs receiver of an air pump, to the upper aperture of which a leathern tube was adapted, with a glaſs tube at the extremity of the leathern pipe, to which the patient applied her mouth, &c.

THE effect of this application was rather diſcouraging. The young lady felt a tightneſs, as ſhe expreſſed it, about her head, for at leaſt three hours after the inhalation of the vital air, and was very reſtleſs at night, in conſequence of which ſhe could not be prevailed on to repeat the inhalation for ſeveral days. At laſt, finding that no other bad conſequence had been produced by it, ſhe conſented to make another trial, which was managed nearly in the ſame manner; but it was attended with much leſs tightneſs about her head, though with an equal degree of reſtleſsneſs at night; notwithſtanding which a third attempt was made on the following day, and the operation was again repeated after an interval of one day.

All thoſe trials were more or leſs attended with the like effects as the firſt; yet our patient thought that, notwithſtanding the reſtleſs nights which ſhe had paſſed, her ſtrength ſeemed to be in ſome meaſure improved, which encouraged us all to follow the application; and in order to avoid both trouble and expence as much as poſſible, we procured one of Mr. Watt's apparatuſes from Birmingham, and ſome good manganeſe from Devonſhire, with which we began to work in a large and more expeditious way.

We found that Mr. Watt's apparatus requires a nicety of management, without which one may do more harm than good. In the firſt trial of this apparatus we got, inſtead of pure air, an exploſive elaſtic fluid; for on lowering a lighted match into a bottle full of it, the air took fire and exploded. It was ſoon found that this inflammability was occaſioned by the moiſture which was contained in the mangeneſe, in conſequence of which the manganeſe was made very dry for the ſubſequent trials, and thus we obtained abundance of oxygen air, which was freed from the carbonic acid air by waſhing in lime water.

BEING now in poſſeſſion of the proper materials, and having ſome expectation of ſucceſs, we began, on the 22d of May, to work aſſiduouſly and regularly; and I took care to note, every three or four days, all the circumſtances that ſeemed at all remarkable.

THREE pints of oxygen air and eight quarts of common air were adminiſtered daily, which conſtantly produced the tightneſs of the head and the reſtleſſneſs at night.

MAY the 28th, the young lady ſeemed to have gained ſtrength; but complaining much of the tightneſs of her head, the quantity of oxygen was diminiſhed to one quart, with eight quarts of common air, per day, which was continued until the 10th of June, by which time her ſtrength was unqueſtionably improved, and the perſpiration at night was conſiderably diminiſhed; but as a cough happened to come on, we intermitted the application of the vital air for a whole week, after which, the cough having diſappeared, the inhalation of the air was recommenced, and continued as before.

BY the beginning of July the good effects of our application were very conſiderable. The ſtrength of the young lady was ſuch as might be expected in a perſon of her time of life; the healthy colour was in great meaſure returned to her face and arms; the perſpiration at night was trifling, and ſhe ſeemed to acquire fleſh.

ON the 15th of Auguſt, the inhalation of the diluted oxygen air was diſcontinued, finding that the young lady's health was completely reſtored.

CASE XIV.

A GENTLEMAN, 35 years of age, of a ſcorbutic habit, and ſubject to violent head-achs, was induced to try the artificial airs in December 1796, every other medical application having proved ineffectual, and his health gradually declining. He was at firſt adviſed to try the diluted oxygen air, which he accordingly did, but after three days inhalation of this air, a conſiderable degree of inflammation on his lungs obliged him to deſiſt.

THE inflammation being ſubdued, he again inhaled the oxygen air, and a ſimilar effect took place, though this ſecond time the inflammation was not ſo conſiderable.

FINDING, therefore, that the oxygen air was not fit for him, he was recommended to drink the water impregnated with carbonic acid gas, and to take ſome other medicines of a demulcent kind. By following this plan for about ſix weeks, and by breathing the ſalubrious air of Devonſhire, his health improved to a certain degree; the ſcorbutic ſymptoms were reduced, and the head-achs were not quite ſo frequent as they uſed to be; but after this improvement, the continuance of the above-mentioned medicines for full three months produced no other effect.

CONSIDERING that in this improved ſtate his conſtitution might, perhaps, bear the ſtimulus of the vital air better than it had done before, he was recommended to try that air again, but to take it in ſmaller quantities. Accordingly he inhaled not more than one pint of it with about ſixteen pints of common air every day, which, not producing any inflammation upon his lungs, he continued for upwards of two months, at the end of which time his head-achs were quite vaniſhed, his digeſtion, which had always been defective, was conſiderably improved, and he reckoned himſelf quite well.

IN the account of the preceding caſes, the reader may obviouſly remark, that not one unſucceſsful caſe has been introduced; on which it will be proper to mention, that in ſo doing I did not mean to impreſs the reader's mind with an exaggerated idea of the power of factitious airs; but that my only meaning was, to render him better acquainted with the practical adminiſtration of the aerial fluids, which ſeemed more likely to be accompliſhed by adducing examples, in which the practice was in ſome meaſure ſanctioned by ſucceſs, than otherwiſe.

WITH reſpect to the eſtimate of the efficacy of factitious airs in different diſorders, my reader muſt conſult the preceding chapter; for I have expreſſed in it the reſult, or what ſeemed to be the fair reſult of all the caſes that have come to my notice; and of ſuch caſes the few that are contained in the preceding pages form a very ſmall part.

I WOULD not be underſtood to mean, that the application of the aerial fluids, in the caſes of the preſent chapter, is to be conſidered as the model of practical perfection, for in ſome of them the adminiſtration is evidently incorrect; but they certainly give a great inſight into the practice, and hope that, with the aſſiſtance of the cautions and remarks of the following chapter, they may in great meaſure prevent the abuſe of a new ſet of remedies, which have all the appearance of becoming very uſeful tools in the hands of ſkilful practitioners.

CHAPTER IX.

PRACTICAL REMARKS, HINTS, &c.

Concerning the Production of Factitious Airs.

IN particular ſituations the difficulty of procuring proper materials and proper tools may prevent the poſſibility of adopting the moſt expeditious, or, upon the whole, the moſt advantageous, methods of procuring the aerial fluids; and when that is the caſe the practitioner muſt conſult the firſt chapter of this eſſay, for the method which may be more ſuitable to the circumſtances of his ſituation. But when there is the opportunity of procuring both materials and inſtruments, it is then proper to follow the plan which may appear leſs exceptionable.

THE cheapeſt article for the production of oxygen air is the mineral called *manganeſe*,

neſe, which is found plentifully in many parts of this iſland, and elſewhere. A very good ſort of it is found near Exeter. It ought to be free from extraneous, and particularly noxious, minerals; but it frequently contains a conſiderable proportion of calcareous matter, which may be detected by powdering a little of the mineral, and pouring ſome nitrous acid upon the powder; for this will produce an effervefcence proportionate to the quantity of calcareous matter. It muſt not, however, be expected to find manganeſe perfectly free from it; for though this may be the caſe with ſmall pieces of that mineral, yet in conſiderably large quantities of it, ſuch as are required for the production of oxygen air, ſome calcareous earth is almoſt always contained; but the only effect which ariſes from it, is the production of carbonic acid gas, together with the oxygen air, the former of which is eaſily ſeparated from the latter by the well-known method of waſhing in lime-water.

'THE greateſt quantity of oxygen air is extricated from manganeſe merely by the action of a full red heat; it is, therefore, neceſſary to put that mineral in a veſſel capable of reſiſting the action of ſuch a degree of heat. Earthen-ware and certain metals are the materials fit for the conſtruction of ſuch veſſels. The former is certainly unexceptionable in point of purity; but it is not managed very eaſily for this purpoſe, and beſides, the uſe of it is attended with conſiderable expence, for a veſſel of that ſort will hardly ever ſerve more than once, as on cooling after the firſt experiment it generally breaks; and indeed it frequently breaks in the courſe of the experiment. Of the metals, gold or platina veſſels would be the fitteſt for the purpoſe, did not their value offer a material objection. Thoſe metals excepted, iron is the beſt; for though the uſe of a veſſel of this metal be attended with evident objections, yet, when managed with care and attention, the oxygen air may be produced of ſuch a degree of purity as to be more than ſufficiently uſeful for medicinal purpoſes.

IT is neceſſary to remark, that in all caſes, but eſpecially when an iron veſſel is uſed, the manganeſe, as well as the veſſel in which it is contained, and the pipe or tube which conveys the air from it to the receiver, muſt be quite free from animal or vegetable matter, and perfectly dry, otherwiſe the elaſtic fluid, which is produced, may be injured in point of purity, and it may even degenerate into a noxious fluid.

WHEN thoſe particulars are attended to, the oxygen air will principally contain a certain proportion of carbonic acid gas, and ſome light powder of manganeſe, the former of which is to be ſeparated by means of lime, and the latter will be depoſited by ſtanding, in about ten or fourteen hours time.

THE ſpecies of inflammable gas moſtly in uſe are extracted by means of diluted vitriolic acid from zinc or iron, and by paſſing the ſteam of water over the ſurface of red hot zinc, or iron, or charcoal.

THE gas, extracted by means of diluted acid, holds in ſuſpenſion ſmall particles of the metals concerned, *viz.* of the zinc or the iron, the latter of which in particular may be rendered manifeſt by burning the gas in a bottle full of it, in which caſe ſome ſmall particles of a dark red light will be diſcerned within the pale flame of the gas, which are the ferrugineous particles; for thoſe minute red ſparks are not to be ſeen in the inflammable gas which is obtained from pond water, or putrid matter, or, in ſhort, from ſuch ſubſtances as do not contain any metallic ſubſtance.

THE gas obtained by paſſing the ſteam of water over red hot zinc, holds in ſuſpenſion a conſiderable quantity of the flowers of zinc, which it depoſits in about a day's time.

THE gas obtained in a ſimilar manner from iron is the moſt abundant, and of courſe the cheapeſt.

FOR the production of the heavy inflammable gas, or hydrocarbonate, Mr. Watt recommends to uſe " charcoal made of the " twigs of ſofter woods, ſuch as willow, " poplar, hazle, birch, or ſycamore, avoid- " ing ſuch as have reſinous or aſtringent " juices. Prepare the charcoal by heating it " to full ignition in an open fire, and " quenching it in clean water, or by filling " a crucible with it, covering it with clean " ſand, and expoſing it to a ſtrong heat in " an air furnace, and then ſuffering it to " cool. In either of theſe caſes it will be " found free from any bituminous matter, " which might contaminate the air, as ge- " nerally happens with common charcoal."

MR. WATT likewiſe mentions, amongſt other ſorts of inflammable gas, that which is extracted from a mixture of charcoal powder and ſlaked lime, which, on account of its peculiar properties ſeems likely to prove very uſeful: "In reſpect, *ſays he*, "to the medicinal properties, all I know is, "that the inflammable air from charcoal "and lime contained no fixed air ſeparable "by waſhing with quick-lime and water, "and that it did not cauſe vertigo when in-"haled pure."

ONE or other of thoſe ſpecies of inflammable gas may be preferred in particular caſes, and it is not only likely, but in great meaſure proved by actual experiment, that the particles of iron, or other matter, which are ſuſpended in a particular ſort of gas, may be peculiarly uſeful in certain diſeaſes.

IN the production of inflammable gas, the introduction of any extraneous matter, and eſpecially of vegetable or animal ſubſtances, and of minerals that contain acids, ſhould be carefully guarded againſt. It is likewiſe adviſable, for a very obvious reaſon, not to conduct this proceſs by candle light.

THE carbonic acid gas may be extracted from chalk in Mr. Watt's apparatus, according to the directions given with the ſaid apparatus; but when no extraordinary large quantity of it is required, it is far more commodious to extract it from chalk or marble powder, and diluted vitriolic acid, in a glaſs veſſel. The difference between chalk and marble in this reſpect is, that the former gives out the gas quicker, but is ſoon exhauſted; whereas the latter gives it out more gradually, and for a greater length of time; hence, in ſome caſes, the former, and in others the latter, may be preferred.

Concerning the Preſervation of Aerial Fluids.

OXYGEN Air is not contaminated by keeping in glaſs receivers, or in ſuch veſſels as do not communicate any thing to it, nor does the contact of pure water injure it; but in wooden veſſels, or veſſels painted with oil paint, and when a conſiderable quantity of common river water is in contact with it, the oxygen air will be contaminated more or leſs.

THE various ſpecies of inflammable gas are apt to degenerate in proceſs of time, eſpecially if they be kept mixed with common or with oxygen air. The hydrocarbonate, in particular, is vaſtly more powerful when freſh made, than two or three days after. Due allowance, therefore, muſt be made for the loſs of power in the adminiſtration of thoſe airs.

WHEN oxygen air, or inflammable gas, is to be taken out of an air-holder or bottle, &c. by putting water in the veſſel after the uſual manner, it is adviſable to uſe lime-water; for the lime will not only abſord any carbonic acid gas that may be mixed with thoſe airs, but will alſo prevent the putrefaction of the water.

FOR this purpoſe there is no occaſion to filtrate the lime-water, as is practiſed in the uſual manner of preparing it; but it will be ſufficient to mix the quick lime with the water, and after leaving it at reſt for an hour or two, to ſeparate the fluid and uſeful part from the ſediment, by decanting it gently.

THE carbonic acid gas is not contaminated by keeping; but as it is abſorbed by moſt fluids, it ſhould not be kept in contact with much water. In moſt caſes it will be better to produce it afreſh every time it is wanted.

IN order to manage the aerial fluids with the greateſt propriety, the practitioner ſhould make himſelf acquainted with the modes of aſcertaining their purity. This may, in great meaſure, be derived from what has been mentioned towards the beginning of this eſſay; but if a more particular deſcription of thoſe methods be required, and eſpecially concerning the uſe of the nitrous-gas eudiometer, or phoſphoric eudiometer, the reader muſt conſult thoſe books which have been written expreſsly on the ſubject of aerial fluids, as the addition of thoſe methods would increaſe the bulk of this eſſay beyond its preſcribed limits.

Concerning the Adminiſtration of Factitious Airs.

WHEN oil-ſilk bags or bladders are uſed, the air or mixture of airs ſhould be introduced immediately before it is to be inhaled, in order to avoid the airs acquiring an unpleaſant flavour.

THE oil-ſilk bags, when not actually in uſe, ſhould be hung up by means of a ſtring, which may be faſtened to the pipe, or they may be put over the back of a chair; but they muſt not be folded or preſſed.

IN the uſual way of making the mixture of airs, the factitious gas, in any required quantity, is firſt introduced in the bag, after which the common air is forced in by means of a common pair of bellows, until the bag is quite inflated; for when the capacity of the bag is once known, one may eaſily determine the quantity of oxygen or other factitious air, which may be required in order to form a mixture in any given proportion.

WHEN common bellows are uſed for this purpoſe, care ſhould be had that they be made free from duſt and aſhes, which are generally contained in ſuch bellows as are uſed for common fire-places.

WHEN a perſon is inhaling any ſpecies of inflammable gas, or the vapour of ether, the operation ſhould be conducted at a diſtance from a candle, leſt the gas ſhould catch fire, and at leaſt occaſion a ſurpriſe.

THE queſtion, which is frequently aſked, whether a patient muſt be confined to his houſe, or to any particular diet, whilſt he is under a courſe of aerial application, ſuggeſts the propriety of obſerving, that there is no particular confinement or diet required merely on that account.

WHEN aerial fluids are adminiſtered, it is proper to feel the patient's pulſe both before and after the inhalation, at leaſt for the three or four firſt inhalations, as thereby one may, in great meaſure, be informed of the effect which the aerial fluid is likely to produce, and may regulate the ſubſequent applications accordingly.

THE patient ſhould be enjoined to breathe the mixture of aerial fluids in an eaſy and natural way, and not in a forced manner, as ſome are apt to do.

WITH ſome perſons the ſenſibility of the lungs is ſo very great, that they are affected with the ſenſation of preternatural heat, and even of inflammation, by a remarkable ſmall quantity of oxygen; half a pint of it, mixed with about twenty times that quantity of common air, has been known to produce ſuch an effect; and this obſervation has been made where there was not the leaſt appearance of miſtake, or of any equivocal circumſtance. This is particularly the caſe with perſons that have recently recovered from an inflammation of the lungs. In ſuch caſes, therefore, the practitioner ought to be particularly careful, and he ought to begin by adminiſtering very ſmall quantities of oxygen.

THE above-mentioned ſenſation of heat generally comes on immediately after the inhalation, but ſometimes it comes on ſome hours after, and eſpecially in bed. It is, therefore, neceſſary to enquire whether any particular effect has been obſerved at any time between one inhalation and the next, in order to form a proper eſtimate of the effect of the application.

WHEN this ſenſation of heat or reſtleſsneſs is in a trifling degree, the daily inhalation may be continued; but it muſt he ſuſpended, or at leaſt moderated, whenever it be found to increaſe by daily repetition.

WHAT has been obſerved with reſpect to the effect of oxygen air, may, with proper and obvious changes, be alſo applied to the inhalation of other aerial fluids, and particularly of the hydrocarbonate.

HOWEVER ſtrange and unaccountable ſome of theſe effects may appear, as that produced by a very ſmall quantity of an aerial fluid in certain circumſtances; or that of the preternatural heat coming on ſo long after the inhalation, &c. my reader may reſt aſſured that the facts are true; and though we cannot reconcile the phænomena with the theory, yet as long as abſurdity does not intervene, we muſt not deviate from the path which is pointed out by experience, becauſe we are unable to underſtand the real cauſes of the effects.

APPENDIX.

On the Nature of Blood.

THE intimate connexion between reſpiration and the ſtate of the blood, the neceſſary dependance of animal life on the oxygen part of the atmoſphere through the intermediation of that fluid, and the various diſcordant opinions which have been entertained concerning the nature of blood; will eaſily excuſe the introduction of this conciſe account of the nature of that fluid in the preſent work, whoſe principal object is the inveſtigation of the action of aerial fluids on the human body.

THE name of blood has been uſed in a more or leſs extended ſenſe by different writers,

writers. Some confine it to the red fluid, which circulates through the veins and the arteries of the animal body; others have, with propriety, extended it to that fluid, which, whether coloured or colourleſs, is the moſt abundant in the animal body, and upon the circulation of which the life of the animal principally depends; hence the red colour is not an abſolute characteriſtic of blood; and, in fact, the blood of certain animals has not the leaſt tint of red. Laſtly, the name of blood has been beſtowed even upon the fluid which circulates through the veſſels of plants.

IN the following pages we ſhall extend our obſervations not farther than the red blood, and hardly beyond that of the human ſpecies; confining ourſelves principally to the account of facts that are independent on particular opinions.

THIS fluid, ſo eſſentially neceſſary to animal life, has been examined with all the ingenuity of man in a mechanical and phyſiological ſenſe, as it circulates through the veſſels of the body; it has been carefully viewed, under a variety of circumſtances, through the moſt powerful microſcopes, and it has been analyzed by the moſt ingenious chemiſts. By this means many diſcoveries have been made, and many doubts have been cleared relatively to it; but after all we can form a very inadequate idea of its extenſive uſe and properties. We muſt, however, remain ſatisfied with the preſent knowledge of facts, and muſt leave the farther inveſtigation of the ſubject to the labours and fortune of future obſervers.

BLOOD is a fluid conſiſting of a great variety of ingredients, ſome of which are always to be found in it; whilſt others are adventitious, or are to be obſerved in it in particular circumſtances; but the proportion of them all is not only various in different ages, and ſexes, and ſtates of the body, but is not the ſame even in the different parts of the ſame body [*]. A difference not ſo great with reſpect to the number, as with reſpect to the proportion, of the ingredients, has been obſerved between the blood of man, and that of other animals, ſuch as the ox, the horſe, the ſheep, the hog, &c. [†].

LEAVING it to the phyſiologiſts to explain how the blood circulates through the ſanguiferous veſſels, how the chyle is mixed with it, how a variety of fluids are ſecreted from it, &c. we ſhall examine its nature as a fluid out of the body.

BLOOD is of a uniform rich red colour, which inclines towards the florid vermilion in blood that comes out of the arteries, and to the dark purple in blood that comes out of the veins, but the latter, as has been obſerved in the preceding pages, becomes brighter by expoſure to reſpirable air. It is not ſo fluid as water, it feels unctuous or ſaponacious to the touch, and has a little ſweetiſh or ſaline taſte.

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[*] Fourcroy found the blood of a human fœtus to differ in three remarkable particulars from that of an adult; viz. it contains no fibrous ſubſtance, ſtrictly ſpeaking, but a ſort of gelatinous matter; it does not take a bright colour from the contact of air; and it does not afford any marks of its containing phoſphoric acid. The colour of blood is paler and thinner in infants, in women, and in phlegmatic perſons, than in men of a healthy and robuſt conſtitution.

[†] Rouelle's Analyſis.

SOON after its extraction from the body, as the blood cools and remains at reſt, a ſpontaneous decompoſition, or ſeparation, of parts takes place. A thick lump of coagulated red matter is formed in the middle, called the *craſſamentum*, or *clot of blood*, and a fluid of a ſlight greeniſh yellow colour ſurrounds it, which is called the *ſerum*. The quantity of ſerum thus formed is leſs at firſt, than a few days after; for as the coagulable part contracts and grows harder, ſo more and more ſerum is forced out of it.

BY waſhing the lump of coagulated matter, the colouring ſubſtance is entirely ſeparated from it, and the remainder is an inſipid,

ſipid, tenacious, white, and fibrous, ſubſtance. The latter is called the *coagulable lymph*, or *fibrous matter*, of the blood. The former, or coloured portion, when viewed through the microſcope, is found to conſiſt entirely of ſeparate particles, circular and pretty uniform in their ſhape; whereas the ſerum and the coagulable lymph, when examined with the beſt microſcopes, do not appear to contain any diſtinct particles in their compoſition.

THE blood, therefore, conſiſts of, or is firſt of all reſolvable into, three diſtinct parts; namely, the *ſerum*, the *coagulable lymph*, and the *red particles*; each of which is likewiſe a compound ſubſtance, but whoſe components cannot be ſo eaſily ſeparated from each other.

THE ſpecific gravity of human blood is variable, but it always exceeds that of water; the latter being to the former, at the leaſt as one to 1,04, and at the moſt as one to 1,063. Each of its three principal components is likewiſe heavier than water; but with reſpect to each other, the red particles are the heavieſt, and the ſerum is the lighteſt.

THE ſerum remains fluid in the uſual temperature of the atmoſphere, as far down as a few degrees below the freezing point. But it coagulates in a degree of heat about equal to 160° of Fahrenheit's thermometer. The coagulation of ſerum by heat is attended with two peculiar circumſtances, *viz.* 1ſt, a conſiderable quantity of air is extricated from it in the act of congelation; and, 2dly, a ſmall part of it does not coagulate, but remains fluid.

THE coagulable lymph has been juſtly conſidered as the moſt important part of the blood, and as being the ſubſtance, from which all the other parts of the animal body derive their increment and their ſupport. The fibrous and tenacious nature of this part, which the blood ſeems to derive from the gluten of our food, is ſo remarkable that it may be ſtretched out to a conſiderable length, and by the continuance of a moderate degree of heat, it may be rendered gradually more and more conſiſtent; ſo that at laſt it may be brought to equal the conſiſtency of horn and even of bone.

THE red particles, from which the whole maſs of blood derives its colour, ſeem to have no particular attraction for each other, nor for the other two components, ſo that in the coagulum they are only entangled and detained by the viſcid part. Their peculiar and uniform ſhape has attracted the attention of philoſophers ſince the latter end of the laſt century, about which time they were firſt diſcovered. They have been attentively examined with the beſt microſcopes, and the appearances which have been partly obſerved and partly ſuppoſed, have given origin to a variety of conjectures and hypotheſes, generally fanciful, and often abſurd.

WHEN any thin and ſemitranſparent part of a living animal, ſuch as the tale of a ſmall a ſmall fiſh, the membrane which is between the toes of a frog, &c. is viewed through a good microſcope; the circulation of the blood through its ſanguiferous veſſels, is rendered manifeſt only by the motion of the red particles, which follow each other at a greater or leſs diſtance; though in general each particle ſeems to touch, or, at leaſt, almoſt to touch the following particle. They never run into each other and incorporate; and though not very hard, they are however poſſeſſed of a certain degree of conſiſtency and elaſticity; for in paſſing through ſmall veſſels they are frequently ſeen to aſſume an elliptical ſhape, and from other ſmaller veſſels they are abſolutely excluded.

THOSE particles loſe their ſhape, and are diſſolved in certain fluids. They are not diſſolved in the ſerous part of the blood, nor in urine, except when they are left in thoſe fluids for ſome days, or when thoſe fluids are diluted with water. But water is a powerful, and almoſt an inſtantaneous, ſolvent of thoſe particles; yet water may be deprived of this property by the addition of common ſalt, or nitre, or of almoſt any other neutral ſalt, as alſo by the admixture of a very ſmall proportion of vitriolic acid.

MARINE acid much diluted with water, does not diſſolve thoſe particles, but it deprives them of their colour.

VINEGAR is likewiſe a ſolvent of the red particles, though not ſo powerful as water.

WHEN thoſe particles have been once dried or diſſolved in water, they cannot, by any known method, be made to reaſſume their former ſhape; and indeed even their formation in the animal body ſeems to be difficultly accompliſhed, at leaſt much leſs expeditiouſly than that of the other components of blood; for in perſons that have loſt much blood, the ſanguiferous veſſels are indeed ſpeedily filled with new blood; but this blood continues thin and pale for a cona conſiderable time, and if examined through the microſcope, few red particles will be found in it.

Unwilling to interrupt the account of the chemical properties of blood, I ſhall reſerve the farther examination of the ſhape and ſize of its red particles for the latter part of this appendix, and ſhall now ſubjoin the farther analyſis of this fluid, which is principally extracted from Fourcroy's late chemical works.

Blood, expoſed to a gentle and continued heat, paſſes into the ſtate of putrid fermentation. When diſtilled on a water bath, it affords a phlegm of a faint ſmell, which is neither acid nor alkaline, but eaſily putrifies, in conſequence of its containing an animal ſubſtance diſſolved through it. Expoſed to a more intenſe heat, blood gradually coagulates and becomes dry; it then loſes ſeven-eighths of its weight, and becomes capable of efferveſcing with acids. Deſiccated blood, expoſed to the open air, attracts from it ſome degree of moiſture; and, in the courſe of a few months, there is formed on it a ſaline effloreſcence, which Rouelle has determined to be carbonate of ſoda. When diſtilled by naked fire, it affords a ſaline phlegm; that is, a phlegm holding in ſolution an ammoniacal ſalt, ſuperſaturated with ammoniac. After this phlegm, a light oil paſſes, then a ponderous coloured oil, and ammoniacal carbonate contaminated with a thick oil. There remains in the retort a ſpungy coal, very difficult to be incinerated, which is found to contain muriate of ſoda, carbonate of ſoda, oxyde of iron, and a matter apparently earthy, which ſeems to be calcareous phoſphate.

BLOOD, when burnt in a crucible, affords ſeveral products, in the following order: 1. water, and a little ammoniac; 2. oil, and carbonate of ammoniac, which forms a yellowiſh vapour, thicker than the former; 3. Pruſſic acid, which is eaſily diſtinguiſhed by its fœtid ſmell of peach-flowers; 4. phoſphoric acid, which is formed by the combuſtion of phoſphorus, and is not diſengaged till the blood be reduced to a coal; 5. carbonate of ſoda, which is volatilized at an intenſe heat; 6. after this there remains in the crucible only a blackiſh, granulated, cryſtallized oxyde of iron, mixed with calcareous phoſphate. The ferrugineous particles of this laſt product may be ſeparated by the magnet, eſpecially when the reſiduum has been previouſly heated together with charcoal-powder in a covered crucible.

Blood combined with alkalis, without previous decompoſition, becomes more fluid by ſtanding. Acids inſtantaneouſly coagulate it, and alter its colour. By filtrating this ſubſtance, evaporating the liquor paſſed through the filter, drying it before a moderate fire, and lixiviating the matter that has been dried, neutral ſalts are obtained, conſiſting of ſoda, with the acid that was mixed with the blood.

IF entire blood, mixed with a fourth part of its weight of water, be coagulated by heat, and if a part of the fluid that ſwims above the coagulated portion be evaporated, a ſubſtance of a brown yellow is obtained, which is eaſily diſtinguiſhed to be true bile.

THE ſerum, which has been lately called the *albuminous fluid*, communicates a green tinge to ſyrup of violets. By diſtillation on a water-bath, it affords a phlegm of a mild inſipid taſte, which is neither acid nor alkaline, but ſpeedily putrifies. After loſing this phlegm, it is dry, hard, and tranſparent like horn: it is no longer ſoluble in water: by diſtillation in a retort, it affords an alkaline phlegm, a conſiderable quantity of ammoniacal carbonate, and a very fœtid thick oil. All theſe products, in general, have a peculiar fœtid ſmell. The coal of the ſerum, when diſtilled by naked fire, almoſt entirely fills the retort. It is ſo difficult to incinerate, that it muſt be kept burning for ſeveral hours, and expoſed to a great deal of freſh air, before it can be reduced to aſhes. The aſhes are of a blackiſh grey colour, and contain muriate and carbonate of ſoda, with calcareous phoſphate.

THE ſerum, if expoſed for ſome time to an hot temperature in an open veſſel, paſſes readily into a ſtate of putrefaction, and then affords a conſiderable quantity of ammoniacal carbonate, with an oil, the ſmell of which is inſufferably nauſeous.

THIS liquor combines with water in any proportion, and then it loſes its conſiſtency, its taſte, its greeniſh colour. When poured into boiling water, coagulates, almoſt wholly, inſtantaneouſly. A portion of this fluid forms, with the water, a ſort of opaque and milky white liquor; which, according to Bucquet, poſſeſſes all the characteriſtic properties of milk, *viz.* it is rarified, and cauſed to mount up, by heat, and is coagulated by the ſame agents, *viz.* by acids, and by alcohol.

THE ſerum poſſeſſes the property of fixing and rendering ſolid by heat, two or three times its weight of water. But when the water exceeds ſeven times the quantity of ſerum, then no coagulation takes place.

ALKALIES render the ſerum more fluid, and acids coagulate it. This laſt mixture, filtrated and evaporated after filtration, affords a neutral ſalt formed of ſoda and the acid employed; which ſhews that ſoda exiſts in the ſerum in a naked ſtate, in full poſſeſſion of all its properties. The coagulum formed in this liquor by the addition of an acid, is very ſpeedily diſſolved in ammoniac, which is the general ſolvent of the albuminous part of the blood; but it is not diſſoluble at all in pure water. Acids precipitate this matter in union with ammoniac. The coagulum affords, by diſtillation, the ſame products as the ſerum deſiccated, and its carbonaceous reſidue contains a good deal of carbonate of ſoda.

THE ſerum, inſpiſſated, affords azotic gas by the action of the nitric acid, with the help of a moderate heat. On increaſing the fire, there is a quantity of nitrous gas diſengaged from the mixture.

THE ſerum does not decompoſe calcareous or aluminous neutral ſalts; but it acts with ſufficient energy in decompoſing metallic ſalts.

THIS fluid is liable to be congealed by alcohol; but this coagulum differs from that formed by means of acids, chiefly for its ſolubility in water.

THE ſerum, therefore, appears to be an animal mucilage, conſiſting of water, acidifiable oily baſes, muriate and carbonate of ſoda, with calcareous phoſphate.

THE clot of the blood affords, by expoſure to the heat of a water-bath, an inſipid water; it becomes, at the ſame time, dry and brittle. It affords, in the retort, an alkaline phlegm, a thick oil, of a fœtid, empyreumatic ſmell, and a good deal of ammoniacal carbonate. The reſiduum which it leaves, is a ſpongy coal, of a ſparkling metallic aſpect, difficult to incinerate, and affording, when treated with ſulphuric acid, ſulphate of ſoda and ſulphate of iron; there remains, after theſe operations, a mixture of calcareous phoſphate with carbonaceous matter. When expoſed to a hot atmoſphere, the clot of blood readily putrifies.

WHEN the clot is divided, by waſhing, into its two principal components, *viz.* the red part which is diſſolved in the water, and the coagulable lymph; if the former be treated with different menſtrua it will be found poſſeſſed of the ſame characteriſtics with the ſerum; excepting that it contains a greater proportion of iron. The latter, after being well waſhed, will remain white, colourleſs, and inſipid. It affords, by diſtillation on a water-bath, an inſipid phlegm, without ſmell, and liable to putrefaction. Even the gentleſt heat hardens this fibrous matter in a ſingular manner. When expoſed ſuddenly to a ſtrong fire it ſhrinks like parchment. By diſtillation, in a retort, it affords an ammoniacal phlegm, a ponderous oil, which is thick and very fœtid, and a good deal of ammoniacal carbonate, contaminated with a portion of oil. The reſidual coal is not very bulky, but compact, ponderous, and eaſier incinerated than that of the ſerum. Its aſhes are very white; it contains no ſaline matter, as it muſt have loſt, by the waſhing, whatever is contained of that kind; and no iron; it is a ſort of reſidue of an earthy appearance, and ſeemingly calcareous phoſphate.

THE fibrous part of the blood putrifies very quickly and eaſily. When expoſed to a hot moiſt atmoſphere, it ſwells, and affords a good deal of ammoniac. It is not ſoluble in water; when boiled in that fluid, it becomes hard, and acquires a grey colour. Alkalies do not diſſolve it, but even the weakeſt acids combine with it. The nitric acid diſengages from it a conſiderable quantity of azotic gas, and of Pruſſic acid, which comes out in vapour, and at length diſſolves it with effervеſcence, and the diſengagement of nitrous gas. When it ceaſes to emit nitrous gas, the reſidue is obſerved to contain oily and ſaline flakes, ſwimming in a yellowiſh liquor: this liquor affords, by evaporation, oxalic acid in cryſtals; and at the ſame time, depoſits no inconſiderable quantity of flakes, compoſed of a peculiar oil, and calcareous phoſphate. It appears, that hydrogene, carbone, and azote, which conſtitute the fibrous ſubſtance, are ſeparated in different proportions, to combine with the oxygen of the nitric acid, and thus form the Pruſſic and carbonic acids that are diſengaged in gas, and the oxalic and malic acids, that remain in ſolution, and are ſeparated only by cryſtallization.

THE fibrous matter diſſolves alſo in the muriatic acid, which converts it into a ſort of green jelly. The acid of vinegar diſſolves it with the help of heat: water, and eſpecially alkalies, precipitate this fibrous matter from acids. This animal matter is decompoſed in theſe combinations; and when ſeparated, by whatever means, from acids, no longer exhibits the ſame properties.

THUS much may ſuffice with reſpect to the chemical properties of blood. I ſhall now return to the examination of the configuration of its red particles, with which I ſhall conclude this eſſay.

THE red particles, which form a very ſmall part of the human blood, were diſcovered by means of the microſcope, towards the end of the laſt century. They were found to be circular and uniform; a tranſparent flat ſurface appearing to be ſurrounded by a dark circumference. This peculiar ſhape ſeemed to indicate their being of ſingular uſe to the animal œconomy, and excited the induſtry of philoſophers to the further inveſtigations of their ſtructure. As this could only be obtained without uſing more perfect microſcopes, and as the perfection of microſcopes depended on the conſtruction of ſmall lenſes, various methods were contrived for the attainment of this object, and microſcopical lenſes of very ſhort focuſes, and of courſe of great magnifying power, were ſoon produced; but the utmoſt power of thoſe lenſes could only diſcover that when the particles of blood were magnified beyond a certain number of times, they exhibited a dark ſpeck in their middle, as a center to their circumference.

THIS is all that could be clearly diſcerned in thoſe particles by means of ground lenſes; but a vaſt deal more was ſuggeſted by the imagination; and it is curious to obſerve how much the eye and the underſtanding were deceived by the natural imperfection of the inſtruments, and by the influence of premature theories.

FINDING that the improvement of ground lenſes, beyond the abovementioned power, was obſtructed by weighty practical difficulties, the deficiency was attempted to be ſupplied by the uſe of globules of glaſs made by melting; for in the ſtate of fuſion, the natural attraction between its particles, will eaſily form the glaſs into a ſpherical body. Several methods were accordingly deviſed for conſtructing thoſe globules, as may be ſeen in Dr. Smith's Optics, and other publications; but thoſe methods are either defective or abſolutely impracticable. And, in fact, I do not find that any globules of very great magnifying power, were uſed before the time of *Father della Torre*, who, about the middle of the preſent century, conſtructed globules of wonderful minuteneſs, and at the ſame time clear and diſtinct.

This Neapolitan Friar, who, without much ſcientific knowledge, poſſeſſed a conſiderable ſhare of ingenuity, made many obſervations with thoſe magnifiers, which he publiſhed, together with a minute and faithful account of his method of conſtructing the glaſs globules, in a pamphlet, about 30 years ago. But both the conſtruction of thoſe globules, and their uſe as magnifiers, are very difficult; ſo that few perſons have attempted to repeat Torre's experiments, and amongſt thoſe, fewer ſtill have been ſucceſsful. This want of ſucceſs has thrown a conſiderable degree of ſuſpicion on Torre's obſervations; and as few people are liberal enough to acknowledge their want of ſufficient patience and addreſs, the failure of the attempts has generally induced people to conſider Torre's aſſertions in the light of miſtakes or exaggerations. "The "Abbé Torre," *ſays a recent writer*, "examined the red particles of blood with "ſimple lenſes too; but they magnified ſo "highly, that from this cauſe all his noiſy "miſtake has ariſen; for he uſed not ground "lenſes, but ſmall ſphericles of glaſs, formed by dropping melted glaſs into water: "they magnified ſo much that to him the "central ſpot appeared much darker; he "ſaid that theſe were not globules, but "rings. He ſent his ſphericles of glaſs, "and his obſervations from Italy, his own "country, to the Royal Society; and for a "long while, though nobody could ſee "them, ſtill the public were annoyed by "Abbé Torre's rings *."

SOME years ago, when Torre's publication firſt became known to me, I endeavoured to conſtruct microſcopical globules after his method, and to repeat his obſervations. The undertaking, which at firſt ſight appeared clear and eaſy, proved on trial very difficult and laborious; however, after perſevering for a conſiderable time, I at laſt procured three or four uſeful globules out of a vaſt number of imperfect ones. With theſe globules, and an apparatus made expreſsly for ſuch delicate experiments, I repeated ſeveral of Torre's obſervations, and (as far as I now recollect, for both the globules and the journal of obſervations have been long ſince loſt) I found that his deſcription of appearances is very accurate, though his conjectures may ſometimes be crude or miſtaken.

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* Bell's Anatomy, vol. ii. p. 89.

BEING lately intent on the ſubject of the preſent work, I was deſirous to repeat the above-mentioned microſcopical obſervations, and for this purpoſe I obtained, after a conſiderable expenditure of time and labour, a few glaſs globules, ſufficiently uſeful, and with them I made the obſervations which I ſhall now lay before the public. But it will be proper to premiſe a conciſe account of the principal opinions that have been entertained by various ingenious perſons, concerning the conſtruction of the red particles, as the origin of ſome of thoſe opinions will be evidently pointed out by the obſervations that follow.

LEEUWENHOECK thought that each red particle of the blood conſiſted of, and was reſolvible into, ſix ſmaller globules, and that every one of theſe ſecondary globules conſiſted of other ſmaller particles. Hewſon took them for bladders which contained a nucleus or central body that ſeemed to roll from one ſide of the bag to the other.

Torre ſaw them like rings; *viz.* conſiſting of an internal and an external circle, and this ring appeared to be divided, or to conſiſt of parts joined together like the rim of a common coach wheel. Falconer conſidered them as flat or ſpheroidical bodies; for he thought he ſometimes ſaw them ſideways. "The red globules," *ſays the late Mr. J. Hunter*, "are always nearly of the "ſame ſize in the ſame animal, and when "in the ſerum do not run into one another "as oil does when divided into ſmall glo-"bules in water. This form, therefore, "does not ariſe ſimply from their not unit-"ing with the ſerum, but they have really "a determined ſhape and ſize. This is "ſimilar to what is obſerved of the globules "in milk; for milk being oily, its globules "are not ſoluble in water; neither do they "conſiſt of ſuch pure oil as to run into "each other; nor will they diſſolve in oil. "I ſuſpect, therefore, that they are regular "bodies, ſo that two of them could not "unite and form one *." Dr. Wells is of opinion, that the red globules conſiſt of two parts, one within the other, and that the outer, being inſoluble in ſerum or dilute ſolutions of neutral ſalts, defends the inner from the action of thoſe fluids *.

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* Treatiſe on the Blood, p. 41.

MUCH having been ſaid againſt the uſe of microſcopical glaſs globules, eſpecially by perſons who had never ſeen them, I thought it neceſſary to aſcertain the limits of the ſuppoſed diſtortion of the image, and other imperfections that had been attributed to them, and for this purpoſe I viewed certain objects of ſimple or determinate figures through lenſes and globules of different powers, increaſing gradually from a magnifying power of about eight or ten as far as that of about 400 times in lineal extenſion.

A DELICATE ſtraight line made by means of a diamond on a piece of glaſs, and which was quite inviſible to the naked

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* Phil. Tranſ. P. II. for 1797.

eye, when thus gradually magnified, appeared always ſtraight, provided it was made to paſs through the axis of the lens or globule. The feathers of a butterfly, or rather any particular part of one of thoſe feathers, never changed its figure though magnified upwards of 400 times.

THERE is an evident diſtortion of the image when the object is viewed through the edge of the lens, and eſpecially of a globule; but no perſon verſed in ſuch experiments will ever obſerve through the edge of lenſes, though the lenſes be ever ſo perfect.

WHEN the object is not very flat, it is then evident that a perfect view of it can not be had at once; for if one part of it be in the focus, the reſt of the object muſt of courſe be out of it; yet by alternately bringing one part of the object and then another to the focus, one may, in moſt caſes, acquire a ſufficiently accurate idea of its ſhape.

VARIOUS obſervations of this ſort gave me reaſon to conclude that the glaſs globules are by no means ſo imperfect as they have been repreſented. Their diſtortion of the image is trifling and limited; the tranſparency of ſome of them (and ſuch only ſhould be uſed) is equal to that of the beſt poliſhed lenſes; but the uſe of thoſe globules is very difficult, and it is on account of this difficulty that they have been neglected and miſrepreſented.

FOR the ſake of thoſe who may be willing to repeat ſuch experiments, I ſhall barely mention the principal difficulties which attend the uſe of the globules.

THEIR focus is conſiderably nearer the ſurface than that of a lens of the ſame magnifying power; and as a globule, in order to magnify more than the uſual microſcopical lenſes, muſt be leſs than the 30th of an inch in diameter, and its focus ſhorter than the hundredth part of an inch, it follows that the common microſcopical apparatuſes are in general inapplicable to ſuch globules, ſince the deviation of one or two thouſandth parts of an inch in the adjuſtment of the focus will occaſion a conſiderable degree of indiſtinction.

IT is for the ſame reaſon, that the globule muſt be ſet ſo as to have part of its ſurface actually out of the braſs cell, and yet it muſt be ſecured ſo as not to drop out.

THE braſs cell muſt admit of the globule being eaſily taken out and replaced; for when they are obſcured by duſt, &c. to which they are very ſubject, they can ſeldom be cleaned without removing them from the cell.—Let us now return to the particles of blood.

I HAVE repeatedly meaſured the diameters of the red particles, both by means of my mother-of-pearl micrometer in a compound microſcope, and likewiſe by looking at them with one eye through a ſingle lens, and referring their image to a ſcale properly divided, and viewed with the other eye out of the microſcope.

IN perſons of nearly the ſame age the mean ſize of the particles differs very little indeed. In the ſame perſon they differ a little, and their figure is not very circular. This deviation from the circle is not ſuch as a flat circular ſurface would aſſume in its different inclinations to the axis of viſion; for, according to the rules of orthographic projection, the flat circular ſurface muſt appear either circular, or elliptical, or as a ſtraight line; whereas I never ſaw the particles of blood as ſtraight lines, *viz.* edgewiſe, and the elliptical figure, which they ſometimes aſſume, is by no means regular.

IN an adult of the human ſpecies, the diameters of the red particles run from about 0,0003 to about 0,0004 parts of an inch, and I very ſeldom ſaw one ſmaller or larger than thoſe limits. If, therefore, we take the ſmalleſt particles and ſet them in a row, we ſhall find that about 3334 of them will equal one inch, and if we take the largeſt, about 2500 of them will meaſure one inch.

WHEN the particles are magnified more than 40 or 50 times, and leſs than 80 (meaning always in diameter), they appear like colourleſs tranſparent ſpots incloſed within dark circles.

WHEN magnified more than 80 times, and leſs than about 160, a dark ſpot, like a dot made with ink on paper, appears in the middle of each particle.

IF the reflector which illumines the particles, inſtead of being ſituated ſtraight before the object, be ſet on one ſide of the axis of viſion, ſo as to throw the light obliquely on the object, then the half of the dark circle of each particle diſappears, *viz.* that half which is on the ſide oppoſite to the reflector. The central ſpot does at the ſame time appear to change its place.

WHEN the particles are magnified above 200 times, the central ſpot appears converted into a circle incloſing a tranſparent ſpace. The diameter of this inner circle is about the half of that of the external one; but the proportion of theſe diameters, or the ſize of the internal circle, may be cauſed to increaſe or decreaſe by the leaſt alteration of the diſtance between the object and the microſcopical lens; and by the ſame means the ſpace within the inner circle may be rendered clearer or darker than that between the two circles. The poſition of the inner circle is changed by the direction of the light; for if the particle of blood be viewed through a microſcopical globule, directly facing the flame of a candle, without the intermediation of any lens or reflector, the inner circle will appear concentric with the outer one; but if the candle be moved a little to one ſide, ſo that the light may fall obliquely on the particle of blood, then the inner circle will be obſerved to move towards the oppoſite ſide, and to acquire an elliptical ſhape.

WHEN the particles of blood are magnified above 400 times, an imperfect image of the candle, which is placed before the microſcope, may be ſeen within the inner circle of each particle.

THROUGH a glaſs globule of 0,018 of an inch in diameter, I have ſeen the red particles of blood magnified about 900 times, in which caſe the image of the flame of the candle could be ſeen within the inner circle of each particle very clearly, at leaſt ſo as to ſhew to which ſide the motion of the air in the room inclined it.

NOTWITHSTANDING this great magnifying power, the annulus or ſpace between the two circles did not appear to be divided, excepting ſome accidental fractures, which now and then could be ſeen in a few of the particles.

THESE obſervations ſeem to prove, that the red particles of blood are not perforated, but that they are globular, and of ſome uniform ſubſtance much leſs tranſparent than glaſs. They likewiſe ſhew that Mr. Hewſon's idea of their containing a central body or nucleus, moveable within the external ſhell, aroſe from the apparent change of place which the various direction of the light produces on the central ſpot or inner circle of each particle. Warned, however, by the example of other obſervers, I ſhall not attempt to offer any farther conjectures concerning the nature and conſtruction of thoſe particles. My reader may draw what concluſion he thinks proper from the abovementioned facts, and he may alſo, with little trouble, ſatisfy his curioſity concerning thoſe appearances, as I find that microſcopical glaſs globules may be had at Mr. Shutleworth's philoſophical inſtrument ſhop on Ludgate Hill. I ſhall therefore conclude with the account of a few experiments which I have made, with a view of imitating the phenomena that are exhibited by the particles of blood, the reſult of which ſeems to corroborate what has been already obſerved.

ON the ſuppoſition of the red particles being globular, I expected that globules of other tranſparent matter would exhibit the ſame appearances as the particles of blood, and my expectations were in great meaſure verified by actual experiments.

A GLASS globule was placed as an object upon the ſtage of the microſcope, and was ſucceſſively viewed through lenſes of various, but not great, magnifying powers. As every part of the globule could not be at once in the focus, the whole of it was not of courſe equally diſtinct. This indiſtinction, however, being not very great, I ſhall proceed without taking any farther notice of it.

THE globule appeared like a dark circular ſurface, with a tranſparent circular ſpot in the middle, and in this ſpot there appeared a diſtinct image of the candle or the window, or, in ſhort, of any other object that was placed directly before it.

IN this experiment three points of difference between the glaſs globule and the particles of blood were remarked, *viz.* 1ſt, that the globule ſhewed a diſtinct, whereas the particle ſhewed an indiſtinct image of the candle; 2dly, that the inner circle of the globule is much ſmaller in compariſon with its external boundary, than the inner circle of the particle is in compariſon with its external one; and, 3dly, that the annulus or ſpace between the two circles is uniformly dark in the glaſs globule, whereas in the particle it is about as clear as the internal ſurface, or rather clearer.

THE firſt and the laſt of theſe points of difference ſeem to depend on the imperfect tranſparency of the particles of blood; for in ſemitranſparent bodies, whatever light falls upon any part of them is ſcattered through the whole body.

THE ſecond point of difference I attributed to the particles of blood being ſurrounded by a coagulated fluid of nearly an equal refracting power with themſelves, whereas the glaſs globule was ſurrounded by air only. In order to verify this ſuppoſition, I placed the glaſs globule in water, and viewing it in that ſtate through the ſame magnifiers that had been uſed before, I found that the tranſparent part or circle appeared much larger than in the former caſe *.

IN the globule of glaſs, as well as in the particle of blood, the inner circle may be made to appear larger or ſmaller, by altering

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* Theſe appearances are perfectly reconcileable to the doctrine of optics. The light, which falls from a luminous object upon the glaſs globule, illuminates at moſt one half of its ſurface, and in entering the ſurface of the glaſs, it is refracted towards the axis of the globule; hence the whole cone of light being contracted, muſt paſs through a ſmall part only of the oppoſite ſurface, and muſt leave the reſt deſtitute of light. Now this contraction of the light muſt vary according to the difference between the refractive power of the globule and that of the ſurrounding medium.

the diſtance between the object and the microſcopical lens.

IN the glaſs globule the inner circle may be ſeen to move from the middle of the dark ſurface, according as the candle is moved from the direct line between the object and the microſcopical lens.

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THE END.